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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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EDWARD CAREY, Registrar
A 57

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TENDERS.

CHEADLE RURAL DISTRICT COUNCIL.

The Council invite

Tenders for the Supply and

FIXING of a NEW or SECOND-HAND 15 ton WEIGHING MACHINE. The Machine is to be fixed at their Stone Quarry at Hemingslow, near Cauldon Lowe. Tenders to be sent in to the undersigned not later than Thursday, the 12th instant, at Five p.m.

By Order,
F. S. COX,
Clerk.

Council Offices,
Cheadle, Staffs.
3rd April, 1923. A 72

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,

are prepared to receive

Tenders for the Supply of—

1. STEEL WORK for Bridges (Bridge over Maduga River).
2. Ditto (Arkonam Branch).
3. Ditto (Footbridge at Tinnevelly).
4. GALVANIZED CORRUGATED SHEETS, etc.
5. PAINTS, etc.
6. MOIST WHITE LEAD.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked: "Tenders for Bridge over Maduga River," or as the case may be, must be left with the undersigned not later than 12 noon on Friday the 20th of April, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of each Specification.

Copies of the Drawings may be obtained at the offices of Messrs. ROBERT WHITE AND PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
3rd April, 1923. A 66

HERNE BAY URBAN DISTRICT COUNCIL.

Tenders are Invited by 16th

April, 1923, for the CONSTRUCTION of a BANDSTAND and SHELTER of Reinforced Concrete, consisting generally of Decking, sustained by piles, retaining walls, enclosing screen walls and roof.

Particulars, Bills of Quantities, etc., may be obtained, and Plans may be seen at the Offices of the Consulting Engineer, Mr. H. KEMPTON DYSON, 17, Warwick Square, Westminster, S.W.1, from Monday, April 9th, to Friday, April 13th, inclusive, upon payment of a deposit of £2, which will be returned on receipt of a *bona fide* Tender. Contractors must have had experience of similar work, and must comply with the requirements of the Unemployment Grants Committee.

The Council do not bind themselves to accept the lowest or any Tender. A 86

METROPOLITAN WATER BOARD.

TENDERS FOR COAL AND ASH HANDLING PLANTS, AUXILIARY BOILER, PIPING, &c., at Littleton Pumping Station.

The Metropolitan Water Board invite

Tenders for the Manufacture,

DELIVERY and FIXING of COAL and ASH HANDLING PLANTS, AUXILIARY BOILER, PIPING, &c., at their Littleton Pumping Station.

Forms of Tender, Conditions of Contract, Specification, and Drawing may be inspected without payment of fee at the Offices of the Board, Chief Engineer's Department, Room 152, New River Head, 173, Rosebery Avenue, Clerkenwell, E.C. 1, on and after Monday, April 9th, 1923.

Contractors desirous of tendering may obtain the necessary documents from Mr. HENRY B. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £1 1s., which sum must be deposited with the Board's Accountant and will be returned on receipt of a *bona fide* tender, together with all incidental papers. Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and Twelve noon).

Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1," and endorsed "Tender for Coal Conveyor, etc., Littleton," must be delivered at the Offices of the Board not later than Ten a.m. on Monday, 30th April, 1923.

G. F. STRINGER,
Clerk to the Board.

Offices of the Board,
New River Head,
Rosebery Avenue, E.C. 1.
28th March, 1923. A 95

LIVERPOOL CORPORATION WATERWORKS.

TRUNK MAIN FROM PRESCOT TO LIVERPOOL—CONTRACTS NOS. 3 AND 6.

TO STEEL BRIDGE AND STEEL WATER-TUBE MANUFACTURERS.

The Water Committee of the Liverpool Corporation is prepared to receive

Tenders from Manufacturers

for the SUPPLY of the following STEELWORK, viz.:—

CONTRACT No. 3.—A Steel Plate Girder Bridge to carry a total distributed load of 40 tons; clear span 71 feet.

CONTRACT No. 6.—Two Steel Tubes of 40 ins. internal diameter; each of a total weight of about 18 tons.

The plans may be inspected and copies of the Specification and Form of Tender for each Contract obtained on and after Monday, 9th April, 1923, at the Water Engineer's Office, Alexandra Buildings, 58, Dale Street, Liverpool, upon payment in each case of the sum of Two Guineas, which amount will be returned upon receipt of a *bona fide* Tender, and return of the documents and drawings issued.

Tenders, endorsed "Tender for Steel Bridge" and "Tender for Steel Tubes," respectively, are to be sent through the post in a sealed envelope addressed, "Chairman of the Water Committee, Town Clerk's Office, Municipal Buildings, Liverpool," so as to be delivered not later than Twelve o'clock Noon on Tuesday, the 24th day of April, 1923.

The Water Committee do not bind themselves to accept the lowest or any other Tender.

W. MOON,
Town Clerk.

Municipal Buildings,
Liverpool.
7th April, 1923. A 81

DEPARTMENT OF PUBLIC WORKS,

Sydney, 31st January, 1923.

SYDNEY HARBOUR BRIDGE TENDERS—EXTENSION OF TIME.

Tenders are Invited by

the Government of New South Wales for the CONSTRUCTION OF THE SUPERSTRUCTURE AND SUBSTRUCTURE OF A CANTILEVER BRIDGE ACROSS SYDNEY HARBOUR FROM DAWES POINT TO MILSON'S POINT, embracing a main span of 1500 feet in the clear, centre to centre of main piers, and a length of main bridge 2600 feet centre to centre of anchor piers. The total length of main bridge and approach spans included in tender is 3810 feet; also an ALTERNATIVE TENDER for the CONSTRUCTION OF THE SUPERSTRUCTURE AND SUBSTRUCTURE OF AN ARCH BRIDGE ACROSS SYDNEY HARBOUR FROM DAWES POINT TO MILSON'S POINT, embracing a main span of 1650 feet in the clear centre to centre of bearings. The total length of main bridge and approach spans included in tender is 3770 feet. Either bridge is to provide for four lines of railway, six lines of vehicular traffic, and footway accommodation.

Copies of Specification, including Plans, Technical Information, General Conditions, and Tender Forms, may be obtained by *bona fide* tenderers on application to the Under Secretary for Public Works, Sydney, or to the Agent-General for New South Wales, Australia House, The Strand, London; the Minister of Railways and Canals, Ottawa; The Australian Trade Commissioner in the United States, New York; or the Bureau of Foreign and Domestic Commerce, Washington, D.C., United States.

Tenders, the time for which has been extended, must reach the Under Secretary for Public Works Sydney, New South Wales, not later than 30th November, 1923.

R. T. BALL, A 59
Minister for Public Works and Railways.

SHEFFIELD CORPORATION TRAMWAYS AND MOTORS.

The Tramways & Motors Committee are prepared to receive

Tenders for the Supply and

DELIVERY of a WHEEL LATHE, suitable for turning and boring Tramcar Wheels and Tyres.

Full particulars and specification on application.

Tenders to be delivered not later than Thursday, 19th April, 1923.

A. R. FEARNLEY, M.Inst.A.E.,
General Manager.

Division Street,
Sheffie'd. A 102

TO METAL MERCHANTS AND OTHERS.

The Rhyl Urban District Council are prepared to receive

Offers for the Taking Down

and REMOVAL of about 300 yards of the RHYL PIER, including the Pier Head.

Particulars and conditions may be obtained from the undersigned.

Sealed Offers endorsed "Rhyl Pier," to be delivered not later than the 21st instant.

T. AMOS JONES,
Clerk to the Council.

Council Offices, Rhyl.
3rd April, 1923. A 85

LITTLE RUSSEL PASSAGE, GUERNSEY.

TOWER ON "ROUSTEL" ROCK and at ST. MARTIN'S POINT.

The St. Peter Port Harbour Committee is prepared to receive

Tenders for the Erection of a

CONCRETE TOWER on Roustel rock, and of a CONCRETE or STONE TOWER, with approaches, upon the rock forming the extremity of St. Martin's point (see Admiralty chart "Guernsey, Herm & Sark").

Plans and Specifications may be seen and Forms of Tender obtained on application to the undersigned.

Tenders are to be enclosed in sealed envelopes, addressed to the President of the St. Peter Port Harbour Committee, endorsed "Tender for Towers," and delivered so as to reach this office on or before Saturday, 28th April next.

The Committee does not bind itself to accept the lowest or any of the Tenders received and reserves the right to accept separate Tenders for the two items.

N.B.—Tenders are asked for now in order to avoid delay, but the Committee cannot enter into any formal contract until authorised thereto by the vote of the States of Guernsey.

(By Order)
J. H. DUQUEMIN,
States Engineer.

States Office, Guernsey.
March 31st, 1923. A 80

MINISTRY OF TRANSPORT.

CONSTRUCTION OF NEW ARTERIAL ROADS.

The Minister is prepared to receive

Tenders for the Con-

STRUCTION of the NEW ARTERIAL ROADS known as

(1) The Kingston By-Pass, and
(2) The Sutton By-Pass, both in the County of Surrey.

Specifications, Bills of Quantities and Forms and Conditions of Tender may be obtained from the Chief Engineer, Roads Department, Ministry of Transport, 7, Whitehall Gardens, S.W.1, upon payment of a deposit of One Hundred Pounds in respect of each scheme. This amount will be returned to the Tenderer, if his Tender is a *bona fide* one, and has not been withdrawn prior to the definite acceptance of a Tender by the Minister.

Conditions of Contract and the Drawings may be inspected at the Ministry between the hours of Ten a.m. and Four p.m.

Tenders must be on the official form, each Tender in a sealed envelope marked "Tender for Kingston By-Pass," or "Tender for Sutton By-Pass."

Tenders must be accompanied by the Specification and Bill of Quantities.

Each Tender must be signed in the handwriting of the Tenderer or his authorised agent.

The Minister does not bind himself to accept the lowest or any tender.

Tenders must reach the undersigned by 10 a.m. on Saturday, the 28th of April, 1923.

Dated this Fifth Day of April, 1923.

H. H. PIGGOTT,
Assistant Secretary.

Ministry of Transport. A 100

APPOINTMENTS OPEN.

SHANGHAI MUNICIPAL COUNCIL.

PUBLIC WORKS DEPARTMENT.

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Four Fully Qualified Clerks

OF WORKS are REQUIRED in the Public Works Department of the Shanghai Municipal Council. Candidates must be about 20 years of age and unmarried. Preference will be given to applicants thoroughly experienced in sewer construction and general engineering work.

Salary, Taels 235 per mensem, under a three years' agreement, which is renewable at a higher salary in the event of satisfactory services. Second-class passage is granted, with half-pay during voyage. Free medical attendance is provided, and the Employee participates in the benefits of a Superannuation Fund. A tael at the present rate of exchange equals 3s. 1d.; exchange is, however subject to fluctuation. Taels 235 per mensem a exchange 3s. 1d. is equivalent to about £527 pe annum.

Particulars of the appointments and also full details as to the benefits enjoyed by Municipal Employees under their Terms of Service, may be obtained from the Council's Agents, and applications in candidates' own handwriting, with full information as to experience, etc., accompanied by copies of at least three recent testimonials, and endorsed "Clerk of Works" on the cover, should be forwarded at the earliest possible moment to:—

Messrs. JOHN POOK & CO.,
Agents for the Municipal Council of Shanghai,
68, Fenchurch Street,
E.C.3. A 90

UNIVERSITY OF LONDON.

The Senate invite

Applications for the Ramsay

Memorial CHAIR of CHEMICAL ENGINEERING tenable at University College.—Full particulars may be obtained from the ACADEMIC REGISTRAR, University of London, South Kensington, London, S.W.7. X773

Wanted, First-class Machine

SHOP INSPECTOR, by large electrical manufacturers in the Midlands, one used to viewing and examining the larger machine parts of electrical machines. Only high grade men with experience in maintaining a high standard of machine shop practice need apply. State age, wages and experience.—Address, A 10, Offices of ENGINEERING.

Engineer.—A Vacancy Occurs

for a well educated ENGINEER to take charge of the manufacture of Wireless Apparatus. Applicants must have first-class knowledge of latest manufacturing methods, and have held responsible positions previously on same or similar work. Permanent position for suitable man. Full particulars of experience, age, and salary required.—Address, A 44, Offices of ENGINEERING.

Assistant Locomotive Super-

INTENDENT WANTED for Railway in Chile. Healthy climate. Age 28 to 30. Must be good draughtsman with general experience. Knowledge of Spanish an advantage. Salary with living allowance equal to £500 per annum. Four years' agreement. First-class passages out and home.—Address, giving full particulars of experience, with copies of testimonials, to A.L.S., c/o STREETS, 30, Cornhill, London, E.C. 3. A 104

CITY OF CARDIFF.

CHIEF STRUCTURAL AND MECHANICAL ENGINEERING ASSISTANT.

Applications are Invited for

the above POSITION in the City Engineer's Department.

Salary £427 10s. per annum, rising by annual increments to £475 per annum (subject to a deduction of five per cent. towards the Corporation Superannuation Fund and to any schemes of adjustment affecting the salaries of the staff generally from time to time).

The person appointed will be required to take control of the Structural and Mechanical Engineering Section of the City Engineer's Department. He should be well qualified in Steel and Reinforced Concrete Construction, and must have had a good experience of Mechanical Engineering, particularly in connection with various types of mechanical vehicles.

Lists of Duties and Forms of Applications can be obtained from Mr. E. J. ELFORD, M.Inst.C.E., City Engineer, City Hall, Cardiff.

Applications, on the prescribed forms, to be sent to the City Engineer not later than Monday, the 16th April, 1923, endorsed "Structural Engineer."

Canvassing, either directly or indirectly, will be deemed a disqualification.

CECIL G. BROWN,
Town Clerk.

City Hall, Cardiff,
28th March, 1923. A 61

Electrical Instruments. —

WANTED, a first-class GENERAL FOREMAN to take charge of Department in Works in the North of England manufacturing electrical instruments, meters, telephones and similar detail apparatus. Must have had experience in this class of work, able to control mixed staff of workpeople, and familiar with up-to-date methods of manufacture on an economical basis. State age, experience, qualifications, and salary required. Copies of recent references to be enclosed.—Address, A 45, Offices of ENGINEERING.

Blueprinting.—Man Wanted

to take charge of Manufacturing Engineers Blue Print Room and Drawing Files. Knowledge of Hall's Rotary Machines and Modern Blueprinting, Photostatic and Reproduction processes essential, together with experience of routine filing and card-indexing.—Address, stating age, experience, and salary required, X 927, Offices of ENGINEERING.

Draughtsman Wanted with

experience in detailing heavy machinery.—Address, stating age, experience and salary desired, A 93, Offices of ENGINEERING.

Machine Tool Draughtsman

for firm in the Manchester District. Must be widely experienced and capable of designing special Machine Tools. Intimate experience of many classes of Machine Tools essential; detailers need not apply. Good prospects for suitable man.—Address, A 29, Offices of ENGINEERING.

THE GAS LIGHT & COKE COMPANY.

CHIEF DRAUGHTSMAN.

Chief Draughtsman Required

by the above Company. Candidates must have had first-class technical training and extensive experience in the design of buildings, structural steelwork, and plant for the mechanical handling of materials. A knowledge of the construction of Gasworks plant and river walls is also desirable.

Applications giving full information as to experience and qualifications, age, salary required, and endorsed "Chief Draughtsman," should be addressed to the CHIEF ENGINEER, THE GAS LIGHT & COKE COMPANY, Horseferry Road, London, S.W.1, on or before 20th April. A 51

A Capable Carriage and

Wagon DRAUGHTSMAN REQUIRED by important Argentine Railway. Age 26-30. Salary £300-£360 with an additional £50 when able to converse in Spanish, free passage.—Write, stating age, education, training, experience, etc., to BOX "B.R.," care of DAVIES & Co., 95, Bishopsgate, E.C. 2. A 103

A Senior Leading Carriage

and WAGON DRAUGHTSMAN REQUIRED by important Argentine Railway, must be capable of taking charge during absence of Chief. Age 28-32. Salary £400-£480 with an additional £80 when able to converse in Spanish, free passage.—Write, stating age, education, training, experience, etc., to BOX "B.R.," care of DAVIES & Co., 95, Bishopsgate, E.C. 2. A 105

HUMIDITY, TEMPERATURE AND VENTILATION OF WEAVING SHEDS.

The Industrial Fatigue Research Board has now published a report by Mr. S. Wyatt, M.Sc., on "Atmospheric Conditions in Weaving" (H.M. Stationery Office, 2*s.* net), based on investigations that the author has been supervising for the Board since it was first appointed (July, 1918). The subject is of interest to engineers for more than one reason. The textile trades are good customers of engineering manufacturers, and must look to them to supply what needs may be disclosed by investigations such as are here described. Ventilation and heating of large closed spaces furnish engineers with tantalising problems, apparently simple but practically complex, in the solution of which it is highly important to know precisely what is wanted, a desideratum that can be recognised more often than satisfied. Simple, for instance, though the statement of what is needed in the atmosphere of a weaving shed seems to be, it has been periodically under examination for the last forty years, but the present report proposes a standard that has never been applied to the industry before, or apparently even recommended as desirable. The operations of weaving sheds, again, are more uniform than those of many industries, and though in some essentials they differ from what is found elsewhere—hot mines, for example—some of their circumstances do occur elsewhere, and the uniformity and large scale of the textile industry makes observations on it likely to be useful in other branches of engineering practice.

The old-standing problem of humidity, temperature and ventilation in weaving sheds has been to reconcile the desirable physical effects on the yarn under manufacture with the undesirable physiological effects on the operatives. This has been the more difficult because until recently what was wrong physiologically was not clearly recognised, and even now the extent to which it affects health seems to be uncertain. The first protest against the artificial humidification of weaving sheds appears, according to the excellent preface by which the present report is introduced, to have been made in 1882, and as the result of an official inquiry by Dr. J. H. Bridges—a distinguished authority—and Mr. E. H. Osborn, it was concluded that the real defect was lack of efficient ventilation, recommendations being made to ensure improvement to a sufficient standard. Accordingly an Act was passed in 1889 requiring at least 600 cub. ft. of fresh air to be supplied per hour for each person employed, and also prescribing for the first time definite maximum humidities for different temperatures. The result not being satisfactory, the Home Office set up a Departmental Committee with Sir Henry Roscoe as chairman, and recommendations made by it were embodied in a Statutory Order in 1897, which added to the existing limits of humidity provisions for controlling rise of temperature by whitewashing roofs and lagging steam pipes, while for the first time a chemical standard of ventilation was introduced, limiting the permissible amount of carbon dioxide to nine volumes in 10,000 of air. Again the result was unsatisfactory, and another Departmental Committee, appointed in 1906, recommended in effect tightening up most of the existing restrictions. The permissible relative humidity, for instance, was to be defined by the difference between dry and wet bulb temperatures, which below 70 deg. F. was limited to 2 deg., with specified higher limits for higher temperatures, no humidification being allowed when the dry bulb temperature was below 50 deg. F. or the wet bulb above 75 deg. F. A standard of efficiency was prescribed for the lagging of steam pipes, and in order to lessen the amount of steam introduced, the standard of ventilation was reduced to eight volumes in excess of the outside air, or about 12 volumes absolute. These provisions were embodied in a Statutory Order, which is still operative; but they failed to give complete satisfaction, and further discussions were in progress in 1914, when they were stopped by the outbreak of war.

Successively, therefore, the best opinion of the day regarded the unquestionable discomfort of weaving sheds as due in the main to want of fresh air, excessive temperature, possibly presence of excessive carbon dioxide, and finally to excess of moisture, as exhibited by dry and wet bulb temperatures; and the present report, basing itself on recent physiological work and following what has already been done in investigations on other industries, adopts the assumption that the dominant influence in making the conditions of weaving sheds tolerable or not is neither the humidity nor the temperature of the atmosphere nor the ventilation of the room, but the cooling power of the atmosphere, which is the resultant of all three and of the velocity of the air. It is no disparagement of the important work on which this assumption depends to recognise that it does not appear either to have begun with or to involve any new discovery in physiology or physics, but is the result of patient and resourceful experiment on phenomena that were known quite well forty years ago. If subsequent experience confirms the validity of this assumption, as seems likely in view of the experimental evidence that already exists to support it, the history set out above may serve to illustrate the need for investigations on industrial fatigue that are based on accurate and apposite experiment and observation, instead of even the best available conjecture or opinion.

The adoption of cooling power as the circumstance that really matters is based on the work of Dr. Leonard Hill, and cooling power is measured most conveniently by his kata-thermometer, which was used in the present investigations. The physical purpose of the kata-thermometer is, as its name denotes, to exhibit a falling temperature, and it is used by physiologists to show the cooling of a fairly large surface through about the same range as the human body at such a rate that it can be stop-watched conveniently and accurately. It is, in fact, an alcohol thermometer with a cylindrical bulb about 2 cm. diameter by 4 cm. long and a stem about 20 cm. long graduated in tenths of a degree from 95 deg. to 100 deg. F., with a small safety bulb at top to accommodate the excess of alcohol when the thermometer is heated beyond its range. When it is to be used the instrument, being normally at a much lower temperature than the range to be measured, must first have its glass brought to about that range, and for that purpose is heated in water of about 180 deg. F. until an unbroken column of alcohol has filled the stem and risen half-way up the safety bulb. It is then withdrawn, left to cool for a minute to allow the glass to assume the range temperature right through, and then reheated, thoroughly dried, and suspended in the position where it is to be read. A reading is the time in seconds, measured by a stop-watch, that the instrument in position takes to fall from 100 deg. to 95 deg. F.; where the air is steady or the instrument in a steady current it is usual to count the average of three to five readings as an observation, but more readings are taken where there is a sequence of currents and calms or an unsteady current. If what is desired to know is the instrument's rate of cooling by radiation and convection, it is used naked; if cooling by evaporation is to be included, a tightly fitting cover of Lisle thread knitted glove is stretched round the bulb, and the excess of moisture jerked off before the instrument is suspended in position. On the assumption that in like circumstances the cooling of the human body would be similar to that of the instrument, the dry reading is what would be given if the instrument were a human body with no visible perspiration, and the wet reading what it would show if it were perspiring.

Having regard to unavoidable variations of surface and thickness no two instruments read alike in identical circumstances, and in order to make the readings of different instruments comparable the thermometric range has to be replaced by a figure for the actual heat per unit surface required to raise the instrument from 95 deg. to 100 deg. F. This determination, made by taking the water equivalent of the thermometer, is done by the makers, and a factor marked on each instrument representing the number of milli-calories per square centimetre of surface that the instrument requires to raise its temperature from 95 deg. to 100 deg. F.; and if this factor—known for want of a better name as the kata factor of the instrument—is divided by the time in seconds that the instrument takes to fall through the range, the quotient is the rate per second in milli-calories per square centimetre at which heat was lost at the test place and time. This quotient is taken to have been the cooling power of the air, and obviously would have been the same for all kata-thermometers placed in the same conditions. Dr. Hill has also found empirical relations between the cooling power of the air so determined, the difference between 97·7 and the air temperature in degrees Fahrenheit, and the air velocity, and tables have been calculated from the empirical equations by which these relations are expressed, giving the air velocity corresponding to each value of the positive temperature difference. For the instrument to be usable the temperatures of the air must not exceed 95 deg. F., or the cooling power of the air for bodies at "body temperature" becomes zero or negative. As might be inferred from the number of readings required to give a trustworthy observation, the instrument is peculiarly sensitive to temporary variations of conditions, and the indications of cooling power can only be taken as approximate. So far, however, they have been found in good agreement with physiological observations, and at least for the time being are likely to be regarded as providing the best criterion to be applied to hot and damp atmospheres. The data are, however, admittedly only approximate, and it may perhaps be hoped that further work may be done on the calibration of the instrument.

The data embodied in the present report consist of a considerable number of observations of temperatures and cooling power made in eight weaving sheds both in winter and summer. The standards of cooling power as measured by the kata-thermometer, that Dr. Hill recommends for rooms in which a sedentary occupation is being pursued, are 6 milli-calories lost per square centimetre per second for the dry instrument and 18 milli-calories for the wet. For weaving, a more than sedentary occupation, doubtless a somewhat higher provision would be desirable; but as a fact even these standards were seldom reached in the observations under notice, though apparently they comply amply with the dry and wet bulb requirements of the last committee. Cooling power gets steadily worse during work hours, and usually recovers somewhat in the dinner hour. The stirring up of the air that occurred when the machinery was running was shown in itself to have a marked cooling effect, and this was easily raised to Dr. Hill's standards and higher by an improvised attachment of a long 3-in. strip of canvas to the heald roller, which made 100 complete oscillations per minute through 180 deg., though the arrangement was not wholly convenient to the worker. The great artificial humidity of the air in these sheds made its cooling power much lower than that observed in most other industries, though the only machine shop quoted—certainly stigmatised as bad—happens to have been rather worse than the average weaving shed. The important practical conclusions of the report are two. On the one hand clothing should be more suitable, especially for women, allowing heat to be lost more readily within the shop, and supplemented by a thick garment to be kept in a cloak room outside the humidified atmosphere. On the other hand, means must be found and applied of artificially increasing the movement of air in the neighbourhood of operatives. These recommendations do not go further than were suggested by Departmental Committees in 1911 and 1914; but they fully confirm the need for putting them in force, and in particular some simple mechanism for increasing the velocity of air without interfering with workers would probably have a wider application than in the weaving sheds for which it is now sought.

MULTI-CUTTING TOOL ARRANGEMENTS.

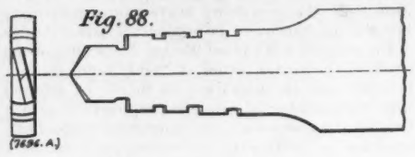
By Joseph Horner.

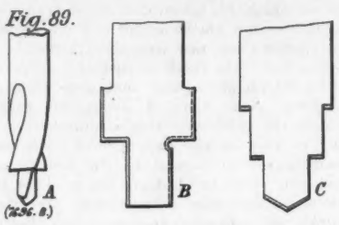
(*Continued from Page* 261.)

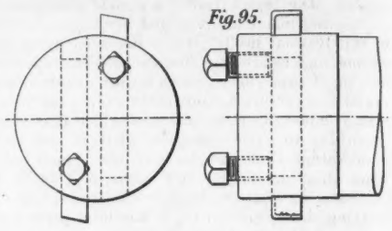
Drilling and Boring.—In these departments, including the allied operations, the multi-cutting methods are illustrated very extensively. Drilling notably, is associated with the use of many spindles, disposed either at variable, or fixed centres, and running in the same or different directions to perform simultaneously all the drilling in a piece of work. Reaming, and tapping may be done on the same or on

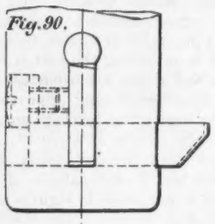
separate machines, counterboring and bossing may also be accomplished. The spindles on a machine may be run at the same, or variable, speeds and are provided to suit holes of different diameters, and to perform reaming, or tapping.

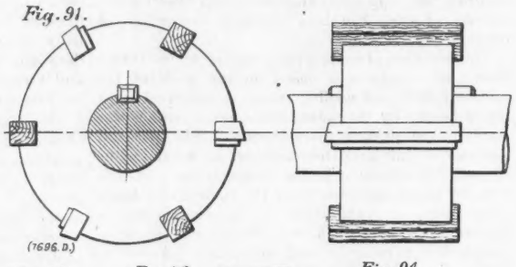
An aspect of multi-cutting that appears in many tools is that of the breaking up of shavings into chips to reduce the stress and quicken the output. An example is seen in the flat drill, Fig. 88, a device which is adopted in roughing reamers, in tools for boring, and in many of the larger milling cutters.

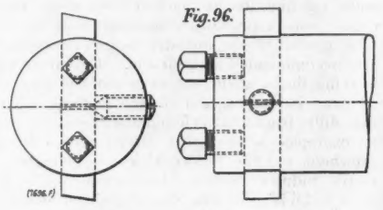


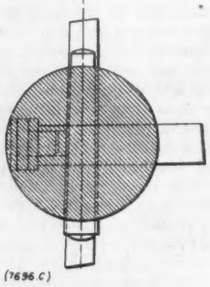


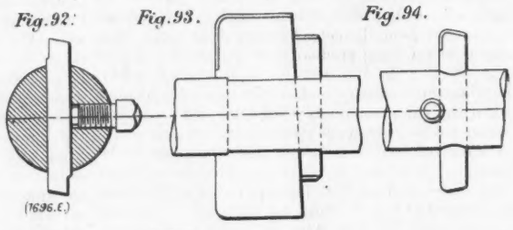


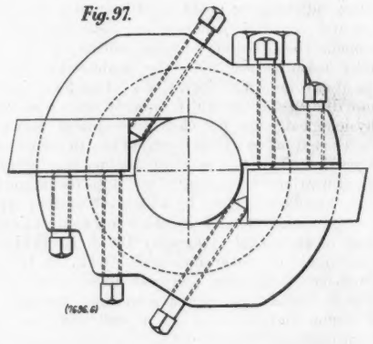


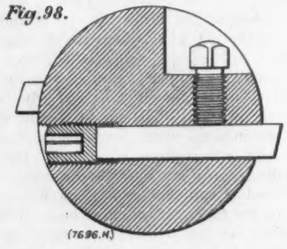


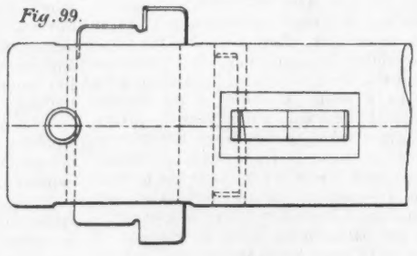


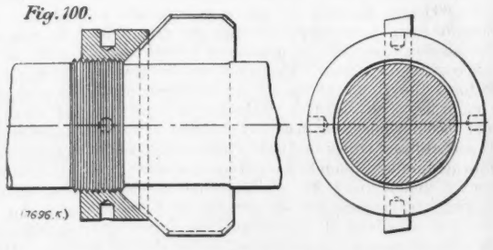


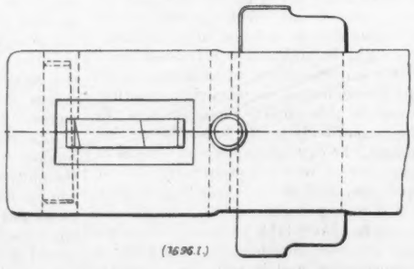












Another case is that of drills cutting more than one diameter. In Fig. 89, A, a twist drill produces two sizes, as do also the flat drills B and C.

The work of boring affords abundant illustrations of multi-cutting, since all boring heads, the smallest excepted, contain more than one cutter. The number commonly increases approximately with diameter. Since the precise setting and fixing of cutters occupies some considerable time, it is usual to have separate heads with their cutters for roughing and finishing. The correct balance of cutters is assured in the multiple heads. They are carried on a bar centred from each end, or otherwise supported, or they project in cantilever fashion from the spindle as in the snout machines, and horizontal machines, and from the turret in lathes of that type and vertical boring machines. The methods of fitting the cutters are diverse.

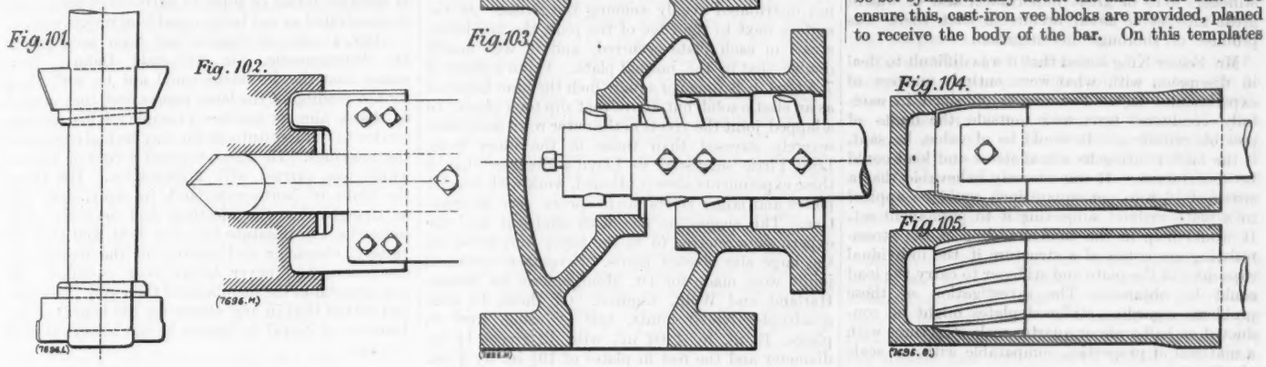
Multi-boring.—The simplest form of boring tool is a single cutter, unbalanced, solid with its shank, or inserted. It is usually a cutting tool with top rake, or side top rake. The overhang of the cutter and bar from its location of support occasions spring of the tool, and inaccuracy in the bore. When practicable, as it is in most instances, cutters are balanced to work on opposite sides of the hole. Or three or more are disposed equi-distantly round the circle. A roughing cutter may be followed closely by one that finishes. The first may be single, the second double-ended (Fig. 90). The single-ended cutter is set radially with the head of a screw, the double-ended cutter is notched to fit over the first and centre it, and the tapered pin secures both. Large bores are treated with heads of cutters on a bar, Fig. 91, which may be finishing tools, as shown, or roughing tools with top rake. The cutters are secured with wedges, or set screws may be used for roughing cutters inserted in holes. The blocks of wood in Fig. 91 serve to steady the head of cutters in the bore. Increasing the number of cutters causes greater severity of stresses, and risk of distortion of thin-walled castings. Yet it does not harmonise with present-day views to reduce speeds and feeds greatly, though some reasonable reduction is necessary with every multiplication of the number of cutters. To favour rigidity, bars and heads are made as large as practicable, and supported either with a pilot, or other means. Roughing tools are commonly ground with top rake, to cut freely, and finishing tools as scrapes. Generally, to allow finishing cutters to follow in the wake of those for roughing is not so good as to mount each in separate heads. The spring of the roughing tools, and the possible distortion of the work renders the finishing cut liable to leave some inaccuracy if effected at the same time. It is usually better to rough first, and finish in another operation, and the finish boring may have to be followed with a reamer when limits are fine.

The larger the number of separate diameters in bores the greater is the economy of multi-cutting from a bar, since with ordinary methods each diameter would require a separate tool setting between each traverse. The multiplication of cutters permits of balancing them by setting them at right or other angles.

Fig. 92 is a double-ended cutter centred as well as may be by hand adjustment, and clamped with one set-screw. Fig. 93 is a flat-finishing cutter, double-ended, centred with a notched portion fitting over the bar, and secured with a wedge. Fig. 94 is a double-ended cutter, set by measurement, and tightened with a tapered pin slightly flattened on the side that makes contact with the cutter. An objection that applies to each of these is that the correct diameter is lost by regrinding. Fig. 95 shows the adjustment of separate cutters which balance each other. They have to be set by gentle tapping, and are then clamped each with a screw in front. A better method and one which is common is shown in Fig. 96. The cutters are set out simultaneously with a conical ended grub screw and are then clamped. Fig. 97 is a section through a boring bar with two cutters, which are adjusted radially by the diagonal screws,

and clamped by the vertical set-screws. A good design is illustrated in Fig. 98, where the cutters are adjusted radially each by a sunk grub-screw turned by means of a tommy in the square recess. Each is clamped with a set-screw, the head of which lies in a recess. The bar is made nearly as large as the diameter to be bored, since the screw heads do not project beyond it.

Fig. 99, illustrates two finishing cutters in tandem, the hinder to finish a different section from the other. Each is centred with a notch fitting over the bar, and secured with a tapered pin flattened on one side. Fig. 100 is a flat cutter centred with a notch, and secured with a circular nut coned to suit the rear end of the cutter, so pushing it against its seating.



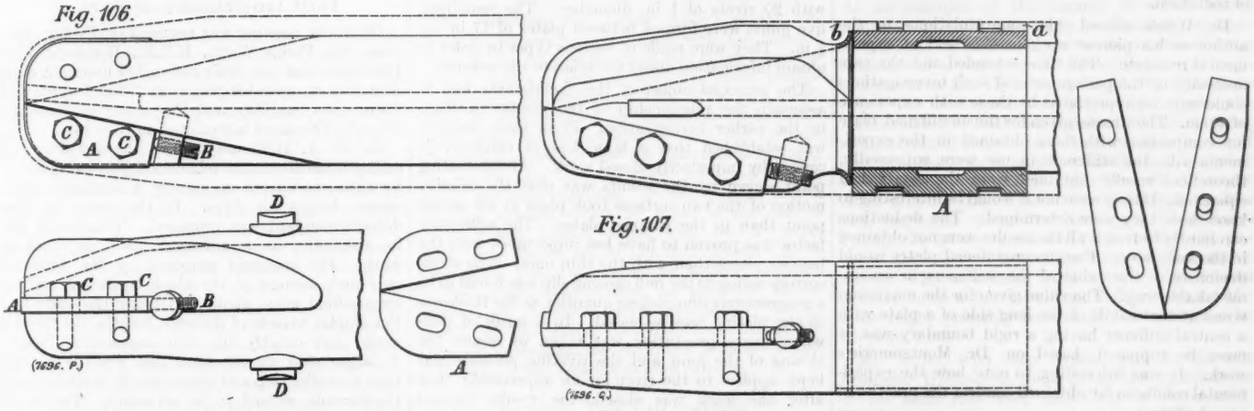


Fig. 101 shows a double-ended finishing cutter which goes through a cylinder bore, and a bell-mouthing cutter above, that chamfers the mouth of the cylinder as the first completes its work. Both are secured with double wedges. In Fig. 102 drilling is combined with recessing. The recessing tools are carried on each side of the drill in a holder through which the drill passes. Multiboring from a single bar is seen in Fig. 103. Three cutters bore plain parallel portions, the fourth forms the recess for the valve seating. Each cutter is held with a set screw. The time of boring is that occupied by the longest parallel portion.

It will be noticed that there is no uniformity in the height of the cutting edges relatively to the centre. The most desirable positions are those in Figs. 97 and 98, where the edges are either on, or slightly below, the centre, because the cutters are then least liable to dig in. In Fig. 95 the setting is below the centre, but this is impossible in the design in Fig. 96, and in the flat double-ended cutters, Figs. 93 and 99. For heavy cutting the cutters should be below, or on the centre, for light cuts the position is of less consequence, and especially if the bar is stiff, and if the bore has to be finished subsequently.

Spade cutters.—The employment of this design of boring tools has arisen from their services in the work of shell boring. They include a variety of designs, being either single-ended, with radial adjustments, or double-ended, cutting on both flanks, Fig. 104, in which case they belong to the great group of form tools. The advantage of these is, that they size, and the cut is balanced, the objection is that they lose their accuracy with regrinding. But they have a good life, and the steel can be used for smaller cutters, and also for preliminary roughing. A form tool is practically a necessity if the correct shape is to be finished. But the overhang is considerable, and the bar must be rigid, or the tool must float for the finishing cut. The methods of grinding the lips vary. Their efficiency largely depends on the degree of care that is exercised both in designing and grinding them, and on the manner in which they are held, and supported to their work. A fine finish can be imparted with a fluted reamer, Fig. 105. Spade cutters may be

divided into two, as many of the common boring bar cutters are treated, with the advantage over the solid forms that fine radial adjustments can be made. Set screws with conical shoulders between the halves may be employed, or lateral setting-up screws, with a clamping screw, or bolts.

Fig. 106 shows how cutters for rough boring the powder pocket of a shell case are made adjustable in the design by Messrs. Laurence, Scott and Co., Limited. The cutters A, A, of high-speed steel, shown separately at the right, are slackened by loosening the backing screws B, and tightened with the fixing screws C, for which elliptical holes are provided in the cutters. The screws B pass through pins that are driven tightly into drilled holes, and filed off flush. The bar is steadied during the boring with three plugs D.

In a later operation the pocket is tooled with the bar in Fig. 107, which is steadied by the phosphor bronze bush A. The cutters are similar to those in Fig. 106, with slot holes for the clamp screws, and backing screws in studs, but they are longer. The steadying bush A is made in halves, and is sunk into a recess, shown without the bush in the lower view. It is retained with bands in the two grooves. A channel is cut along the bush at *a* through which the coolant escapes backwards, after having been forced through the tube seen, to the cutters. A leather washer *b* is bound round the bar to prevent water getting between it and the bush. A grease chamber about the centre of the bush lubricates it.

In order to get the best results, it is essential that the two cutting lips shall do exactly the same amount of work, which requires that the edges shall be set symmetrically about the axis of the bar. To ensure this, cast-iron vee blocks are provided, planed to receive the body of the bar. On this templates are fixed up and dowelled, and by means of these the tool setter adjusts the cutters, doing so on one side in the first place, after which the bar is rotated through 180 deg. when the cutter on the opposite side is similarly adjusted. This work is done in the tool-room. Sections of the cutters used for roughing, and finishing are shown in Figs. 108, 109. A copious flow of coolant is employed. The used liquid falls through the beds of the machines into gutters leading to a series of settling, and filtering tanks.

(*To be continued.*)

INSTITUTION OF NAVAL ARCHITECTS.

(*Concluded from page* 392.)

AT the opening of the meeting on Friday morning, the President called upon the secretary to read the names of proposed new members. The list was a long one and the occasion was made outstanding by the inclusion for the first time of the name of a lady, Miss Keary, of the National Physical Laboratory, who was elected an associate member.

STIFFENED PLATING.

The President then asked Professor T. B. Abell to read a paper on "The Behaviour of Stiffened Thin Plating under Water Pressure." In his paper, Professor Abell described an apparatus designed by him for use in various types of investigations on the effects of pressure upon plating and gave the results of the early experiments which have been

conducted with it. The paper is reprinted on page 445 of the present issue.

Sir Westcott Abell opened the discussion and congratulated his brother on having devised an apparatus by means of which boundary conditions in ship plating may be investigated in a more thorough way than has previously been possible. The author got over the difficulties of the lack of absolute contact between the plate and the cover-plate at its edge by starting the faired curves from an assumed zero deflection at a point half-an-inch under the cover-plate. He thought that it may be possible to establish contour lines of contact and start the curves at varying distances from the ends according to the observations. The actions of stiffeners were of great importance, and it was of great interest to naval architects that there was promise of thorough investigation.

Mr. Foster King stated that it was difficult to deal in discussion with what were entirely matters of experimental fact. The results obtained in carefully conducted tests were outside the limits of possible criticism. It would be of value, he said, if the facts relating to actual stress and load could be determined. It was scarcely believable that a stress of 16 tons per square inch could be applied to a plate without subjecting it to permanent set. It would help in the understanding of the stress-resisting properties of a structure if the individual capacities of the plate and stiffener to carry the load could be obtained. The investigation of these problems regarding stiffened plates might be conducted on half-scale or quarter-scale structures with a material of properties, comparable with the scale of reduction.

Dr. Welch offered his congratulations to the author on his pioneer work in this field of experimental research. The time expended and the care necessary in the performance of such investigations could only be appreciated by those with experience of them. The stresses given for the unstiffened plate for comparison with those obtained in the experiments with the stiffeners in use were, supposedly, theoretical results obtained from the established equations. If they were not it would be interesting to know how they were determined. The deductions can hardly be true if all the results were not obtained in the same way. Tests on unstiffened plates would demonstrate the value of the stiffeners in an unmistakable way. The value given for the maximum stress at the middle of the long side of a plate with a central stiffener having a rigid boundary was, it must be supposed, based on Dr. Montgomerie's work. It was interesting to note how the experimental results so far obtained confirm the practice of recent years.

Dr. Laws continued the discussion by references to the large amount of labour involved in any research work and spoke of the reasons for abandoning the process of riveting the stiffener to the plate. The deflections of the plate were so great that it was impossible to determine the dimensions. When the bolted construction was adopted the troubles were overcome. This research work was providing information regarding the distribution of the stresses, and designers must not be guided solely by the general stress over the whole plate. The object of all the investigation work was to see if it was possible to reduce the maximum stress actions which were operative.

Mr. Bailey hoped that experimental work may be continued until they have an accurate knowledge of how far designers were justified in reducing scantlings. The method of dealing with the stress at the boundaries of the plate could not give absolute results, and it would be informative if the apparatus could be used for tests with plates carrying stiffeners over the ends of the boundary bars.

In reply to the discussion Professor Abell agreed with the views of Mr. Bailey regarding the method of dealing with the deflections on the basis of no deflection at half-an-inch distance in the cover and owned that the results could not be regarded as absolute, but the method adopted was a reasonable one. Other speakers also referred to the boundary conditions, but must recognise the extraordinary difficulties involved. The values of the stress given for the unstiffened plate were those obtained from the beam formula and from Dr. Law's work on panels, where the length is four times the breadth. The effect of the stiffener and the plate must be dealt with together as one unit. Little light could be obtained from dealing with them as separate entities.

Large Riveted Joints.

In the next paper, which we hope to print in a future issue, Dr. Montgomerie presented the results of "Further Experiments on Large Riveted Joints." In the years 1917 to 1920 the author conducted an experimental research on the elastic properties of riveted overlap joints. The results were embodied in a report presented to the Committee of Lloyd's Register, which was published by them in May, 1920. These experiments showed that the load was not distributed evenly amoung the rivets. At the surface next to the edge of the joint the maximum stress in each plate occurred, and it was nearly double that in the normal plate. Up to a stress of 7·5 tons to 8 tons per square inch the joint behaved as an elastic solid, but above that slip took place. In a lapped joint the rivets in the outer rows were more severely stressed than those in the inner rows. Lord Pirrie suggested to Lloyd's Register that if these experiments were continued, work with heavier plates and larger rivets might prove very informative. This suggestion met with approval, and the experiments referred to in the paper were those on the large size riveted joints. Seventeen specimen joints were made for Dr. Montgomerie by Messrs. Harland and Wolff, Limited. Of these, 12 were quadruple riveted joints, half of which were in plates, 13 in. by 1·04 in., with 12 rivets 1¼ in. diameter and the rest in plates of 19½ in. by ⅞ in., with 20 rivets of 1 in. diameter. The remaining five joints were formed between plates of 17 in. by ⅝ in. They were made of various types in order to obtain information about the relative slip actions.

The principal object of the experiments was to ascertain the relationship of the results to those in the earlier investigation. From these tests it was established that a large loss of efficiency is caused by imperfectly closed work. An interesting point shown by the results was that the relative motion of the two surfaces took place at an earlier point than in the thinner plates. The adherence factor was proven to have less importance with the heavier plates than with the thin ones. The stress corresponding to the pull causing slip was found to be a progressively diminishing quantity as the thickness of the plating was increased. In a series of tests where every precaution was taken to ensure the closing of the joint and the riveting pressure was kept applied to the rivet for an appreciable time after the work was closed, the results showed increased values for the slip stress. One of the important deductions was that the adhesion factor must be as high as possible. The total resistance of the joint was shown to be compounded of that frictional factor and the shearing resistance of the rivets, and it appeared to be certain that the two did not act simultaneously. Accompanying the paper a voluminous bibliography of the work on riveted joints was given.

Mr. Stromeyer opened the discussion on the paper and gave information relating to tests upon two old boilers to find the influence of age on the strength of iron. In the series of experiments it was found that slip took place in the riveted joints at between 3 tons and 7 tons. One example cited, where there was a crack 5 ft. 6 in. long at the joint the friction effects had prevented the rupture of the boiler.

Sir Westcott Abell called attention to the necessity for well-closed joints and the consequent increased adhesion. Below the slip values the results showed that these joints could be considered as elastic solids and that the joints used in boiler construction were satisfactory. The tests showed figures in excess of anything experienced in a boiler under sea-going conditions.

Mr. Foster King welcomed the addition to the literature of the subject made by Dr. Montgomerie, and spoke of the benefits of using large testing machines and specimens in such work. The results obtained were much more satisfactory from the standpoint of practice. "Stiction" between the plates was demonstrated as the most important factor in any riveted joint.

Dr. Montgomerie in reply, said he was very much interested in the contribution of Mr. Stromeyer. It said much for the quality of the workmanship in the construction of boilers many years ago, that such good results were obtained. The breaking strength of riveted joints has been found over and over again, and, though some of the speakers suggested that that information might have been given, it served little purpose, for what was wanted was knowledge on the behaviour of riveted joints in use. The generous contributions to the literature on the subject by early writers was borne out in the bibliography, and it was interesting to note that riveted joints have remained unchanged throughout the last 40 years. What were selected as suitable forms of joint in early days have been demonstrated as not being capable of improvement.

After a vote of thanks had been accorded to Dr. Montgomerie, Sir Archibald Denny, Bart, stated that the President could not be with them for the reading of the later papers and they wished to thank him for another example of his untiring service to the Institute, in the way he had conducted the meetings. He then proposed a vote of thanks, which was carried with acclamation. His Grace the Duke of Northumberland, in reply, said that he thought that the meetings had been the most successful the Institute had ever held, and that the variety, character and interest of the papers and discussions had never before been equalled. He was grateful to the members for their vote of thanks, and stated that in any efforts for the benefit of the Institute of Naval Architects he was always at their service.

Form and Stability of Ships.

When the meeting was resumed on Friday afternoon, Sir Philip Watts, K.C.B., Honorary Vice-President, took the chair and called upon Mr. John Anderson to read his paper on "The Influence of Form upon Stability and Propulsion of Passenger Ships." The paper is reprinted on page 444.

Dr. P. A. Hillhouse opened the discussion by calling attention to the reluctance, previously shown by naval architects, to specify a minimum metacentric height for ships. In the paper the first definite standard was proposed. Time would test its suitability as a universal basis on which to work. The standard proposed by Mr. Anderson only took account of the block coefficient and the longitudinal areas above and below the water line. For similar vessels of different lengths the formula would give exactly the same metacentric height. A larger ship should have less relative breadth than a smaller ship and consequently modification of the formula seemed to be necessary. The use of bulges as a part of the structure of a ship would produce improvements in the propulsion. He showed comparisons of the minimum stability on Mr. Anderson's standard with the values for three different types of vessel, by plotting the draught as ordinates and the minimum G.M. as abscissæ. In the loaded condition the point for the Anderson value came above the graph for the Empress of Britain, but the points for condition of arrival in harbour and light were below the graph. In the other two cases all three points for each were below the curves. The ships considered were all of satisfactory stability. Whether the formula gives results too high or too low would only be settled by the accumulation of experience.

Sir Westcott Abell spoke of the complexity of the stability problem. Compromise was essential between the many conflicting conditions, but the proposal of the formula was to be welcomed as a first approximation. Arrival conditions should be taken as the standard. The proposed scheme was, he thought, based on statical considerations only. The author recognised that modification might be necessary, and admitted that it was requisite to introduce a factor for a damaged condition.

Professor Welch stated that the formula was based on the fact that different ships should heel to the same angle for the same wind pressure if the ratio of depth to breadth was constant. The author of the paper indicated a liking for deep tanks, but it seemed preferable to increase the depth of the vessel. It was thought by many to be better to have one foot G.M. in the light condition.

Mr. A. T. Wall said that the author quoted Mr. Peskett as saying that the G.M. should be the minimum commensurate with safety, but it must be remembered that the reference was to the arrival condition. Extra metacentric height was good. It was thought better to have a margin and work on the basis of the arrival conditions. The formula proposed was a reasonable basis, as far as metacentric height was concerned, but the G.M. under certain conditions was no criterion of the stability. In Table III of the paper, comparisons were made between an original vessel E, a similar design G, with the beam increased to obtain the proposed metacentric height and H, altered to the proposed form to obtain the desired stability in loaded and ballast trim. In this comparison G appeared to be quite as good a ship as H, the one of the form proposed by the author. On the grounds solely of stability considerations it was difficult to see the reason for the proposed form. Mr. Telfer referred to a proposal regarding the use of bulges in which the shape and position of the bulge would be decided after the ship had been built.

In reply Mr. Anderson thanked the contributors for the interest they had shown in his suggestions. The method of getting the required stability in the cheapest way possible was to make use of bulges. By their installation the general increase of breadth of the ship would be avoided and they could be shaped to suit the conditions of loading.

On the motion of the chairman, Mr. Anderson was accorded a hearty vote of thanks.

The Effect of Loading on the Structural Stresses in Ships.

The next paper taken was one by Mr. W. Thomson dealing with the effect of variations in loading on the longitudinal structural stresses in ships; this paper we hope to reprint in a later issue. On being called upon by the chairman, the author said he proposed not to read his paper in full but to indicate briefly the nature of its contents. The object of the paper, we may explain, is to consider typical cases of loading which depart in a marked degree from those generally assumed and to draw some conclusions regarding the manner in which the cargo should be stored to prevent undue stresses from being developed in the structure. The author first considers the case of a steamer of 10,000 tons cargo capacity, giving the bending moments and shearing forces with the machinery amidships or aft when carrying homogeneous cargo or a cargo of iron ore. It is shown that with a vessel carrying ore, there is a decided increase in the bending moment in the sagging condition when the machinery is fitted aft; the shearing forces are, in all cases, greater for the ore cargo than for the homogeneous cargo. In the case of a cargo vessel in ballast condition, the author shows that when two deep tanks amidships contain ballast, the bending moment, when sagging, is fully 50 per cent. greater than in the normal loaded condition. Oil-carrying steamers with various degrees of loading and in the ballast condition, are also considered and the author shows that by an injudicious arrangement of the load when the vessel is only partly loaded the bending moments reached greatly exceed those obtained with full load. In one example, that of an oil steamer with three tanks empty, the excess of bending moment amounts to 42 per cent. and the excess shearing force to 55 per cent. The remainder of the paper deals with the stresses due to bending moments and shearing forces, and to show how these may vary with the loading we may quote the figures given in the paper for a 500 ft. oil steamer. The author shows that with three tanks empty, the fact that the empty tanks may be situated either amidships or at the ends makes it possible to alter the compressive stress in the deck plating from 4·8 tons per square inch to 10·6 tons per square inch, while the corresponding stress under standard loading conditions would be 7·5 tons per square inch.

The discussion on this paper was opened by Mr. Foster King, who said the question of sagging stresses was becoming of increasing importance. The conventional idea had been not to trouble about sagging stresses, but in recent years cases such as those indicated by the author had had to be faced. It was not reasonable to provide a structure to withstand stresses so greatly exceeding the normal, and it was therefore incumbent upon the shipowner to take proper precautions with respect to the loading. Finally, the speaker thought the author deserved thanks for bringing out the fact that to secure satisfactory results it was necessary not to depend entirely upon the man who designed the structure.

The only other speaker on the paper was Sir Westcott Abell, who agreed with Mr. Foster King that the shipowner often departed from the conditions for which the vessel was designed. By injudicious loading, as the paper showed, the stress could be doubled. An important point was well brought out by one of the illustrations in the paper relating to an oil vessel with three tanks empty and seven filled. In this condition, by merely transferring the contents of one tank amidships to another near the forward end, the stress on the vessel could be halved. Actually, the speaker pointed out, conditions were not usually so serious for oil ships since the masters of these vessels were generally provided with loading diagrams. He also thought the author's figures for the stresses were on the high side, and added that they did not appear to agree with the usual formula. He further pointed out that while the transverse system of framing had been considered in the paper, a large number of oil vessels were now constructed with longitudinal framing with which the stresses would be much less. The paper had, however, been found very useful at Lloyd's Register and the speaker hoped it would also be useful to shipowners.

Mr. Thomson then briefly replied to the two speakers, expressing agreement with the remarks of Mr. Foster King to the effect that it was unreasonable to design a ship to meet the worst possible conditions. In answer to Sir Westcott Abell's observations that some of the stresses given in the paper were not in accordance with the formula, the speaker explained that the difference was largely due to the fact that the stress was taken in the line of the deck openings. It was true, he added, that the stresses would be lower in the case of longitudinally framed ships, and, on a paper basis, they would be 30 per cent. lower. As to how much reduction could be actually credited to the longitudinal system, he preferred not to express an opinion, since authorities differed greatly on this point. At the conclusion of Mr. Thomson's remarks, the chairman proposed a vote of thanks to him, which was duly carried.

Graphical Trim Calculations.

The last paper on the programme was entitled "Graphical Trim Calculation and a Trim Nomogram," and it contained the results of part of the work upon which its author, Mr. E. V. Telfer, has been engaged during his tenure of the Research Scholarship awarded by the Commissioners of the 1851 Exhibition, to which he was appointed by the Council of the Institution in October, 1920. The object of the paper, which we hope to reprint later, is to develop a graphical method of trim calculation known as Long's trim curves, and it shows that the method is merely a more convenient presentation of the metacentric method of calculation. The author examines the geometry of trim curves, their presentation and practical manipulation, finally presenting them in the form of a trim nomogram, or alignment chart. He illustrates the use of this nomogram and expresses the hope that it may be adopted not only by naval architects but by draughtsmen and ships' captains.

Mr. Telfer rapidly explained the chief points of his paper, remarking, after he had done so, that it had a direct relationship with the previous paper in that the trim nomogram would assist a ship's captain to determine what was a judicious loading.

The first speaker in the discussion on Mr. Telfer's paper was Professor Hillhouse, who remarked that he had not studied the paper closely but saw that it reduced the trim problem to the form of a simple diagram. The latter, he thought, would involve a great deal of work to prepare, but once prepared, would be easy to use. The speaker was not himself a great believer in the nomogram, preferring to carry a slide rule which had the advantage that it could be applied to any problem whereas a nomogram had to be specially prepared for each. He doubted whether a ship's captain would make much use of the nomogram, having found that the simpler the form in which the information was made available the more likely it was to be used. The degree of accuracy aimed at in the author's nomogram the speaker regarded as excessive from the ship captain's point of view, and he thought it sufficient for practical purposes to give a capacity plan of the ship marked so that the effect on the draught fore and aft of filling or emptying any particular hold could be seen at a glance. This method did not, of course, pretend to great accuracy under all conditions, but it would be accurate at one particular draught and near enough for practical purposes at other draughts.

The next speaker, Professor J. J. Welch, said he thought the principal object of the paper was to show how the construction of the nomogram could be applied to shipbuilding problems. He was inclined to agree with Professor Hillhouse that something very simple was needed for the use of ship's captains but he thought they should be given the opportunity of using such a diagram if they cared to avail themselves of it; its great accuracy was so much to the good.

Mr. G. S. Baker, the only other speaker on the paper, said it was an excellent example of the good arising from the scholarships which the Institution had at its command. It was the second paper read by the author within the last few months and the speaker had derived much benefit from both. As an example of the manner in which useful information could sometimes be obtained, he mentioned that he had been previously unaware of the existence of a paper by M. d'Ocagne, referred to in a footnote to Mr. Telfer's paper. In M. d'Ocagne's paper the nomogram was utilised to express the mathematical relationship involved in the stopping and starting of ships. In connection with the use of graphical methods in naval architecture, the speaker added that it was now 24 years since Sir Westcott Abell and he had come across Bonjean's profiles and employed them for destroyer calculations. Finally the speaker remarked, with reference to the use of the nomogram by ships' captains, that many persons who now held tank tests in high esteem did not do so a few years ago, and he thought the same might probably be said of the nomogram in 10 years time.

Mr. Telfer, who then replied, said he thought Professor Hillhouse's remarks on the omniscience of the slide rule were rather to be deprecated. The fact that this instrument did not indicate the position of the decimal point was a bugbear to captains. With the nomogram, on the other hand, the position of the decimal point was settled once and for all, and moreover all the scales were perfectly even and standardised; the only difficulty he added, lay in the locus of the trim points. He thought the method would appeal to draughtsmen and once they were familiar with it, its use would extend. Reference had been made to the meticulous accuracy of the nomogram, and on this point he remarked that he had thought it as well to show that no degree of accuracy was too great for the method, but such high accuracy need not be used in practical applications. He greatly appreciated Mr. Baker's remarks, and in connection with them wished to refer to a point in the history of naval architecture. The actual curves referred to as Bonjean's profiles, he said, were not due to Bonjean, all the latter did being to embody in them one of the principles of nomographic calculation.

The chairman then proposed a vote of thanks to Mr. Telfer, which was duly carried, and after votes of thanks to the Royal United Service Institution, to the Council, and to the secretary and his staff had also been passed, the proceedings terminated.

German Electrical Industry.—We read in the *Landbote und Tagblatt der Stadt Winterthur* that the electrical concern, formerly Schuckert and Co., now belonging to the Stinnes Siemens-Rhein-Elbe-Union, has distributed a dividend of 66⅔ per cent., as against 16⅔ per cent. in the preceding year.

A NOTE ON HYDRAULICS.

THERE is a remarkable difference in the behaviour of fluids moving past solid surfaces according as the surface is an external or an internal one. In the case of a pipe, if the speed of flow exceeds a certain limit, the motion becomes turbulent, and this turbulence extends right across the pipe. Nothing analogous to this occurs when the fluid flows past a solid surface immersed in it and situated at a considerable distance from opposing surfaces. In such case the turbulence never extends far from the surface washed, and some physical explanation of this peculiarity seems needed. Some light on this question seems to be afforded by certain properties of vortices. That pipe friction must tend to produce vortices seems to be definitely established by experiments with a smoke-box which prove that the friction at the edge of the orifice is capable of producing a smoke ring. Could corresponding vortex rings be produced and maintained in pipes, a large discharge would be obtained with a very small loss of head. Experience shows, however, that flow of this type is impossible in pipes, and at any rate one reason for this impossibility seems fairly clear from a consideration of certain characteristic properties of vortices.

If we have two vortices such as are represented diagrammatically in Fig. 1, each vortex has an influence on the other. Under the influence of A, the vortex B tends to rotate round A in the direction indicated by the arrow in A, whilst under the influence of B, the vortex A tends to rotate round B in the direction shown by the arrow in B, and assuming the two vortices to be of the same strength, the result is that both move forward in the direction indicated by the central arrow. The two vortices represented in the figure may, of course, be regarded as the section of a smoke ring taken through its axis.

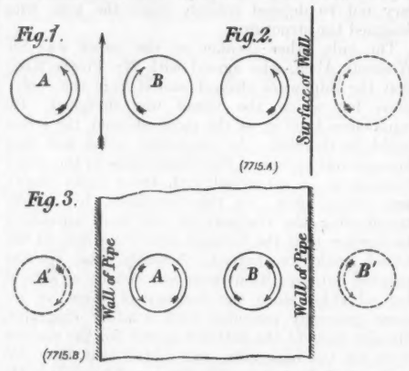
Consider next the case of a solitary vortex. If this comes near a solid wall as represented in Fig. 2, it moves as if it were in the presence of a second vortex corresponding to a mirror image of itself. This image is represented by the dotted circle in Fig. 2, where the heavy central line is intended to indicate the wall in which the real vortex "sees" its reflection, and moves exactly as if this reflection were real.

Now assume that it is possible for a vortex ring to be formed in a pipe, and that the diameter of the core of this ring is not very small in comparison with the pipe diameter. The condition of affairs will now be as is represented in Fig. 3, where the reflections or imaginary vortices are represented by dotted circles. The reciprocal action of the real vortices tends to produce motion in the direction indicated by the central arrow in Fig. 1, but *vis-a-vis* to its image each real vortex tends to move in exactly the opposite direction. As the two influences are of similar strength, the real vortex ring is torn in pieces and we get turbulence filling practically the whole of the pipe. That it is possible to produce rings with a smoke-box seems to be due to the narrowness of the edge of the orifice, which thus presents too small a surface for the due formation of the reflected image.

From the foregoing considerations we may conclude that we cannot maintain a stationary vortex in the neighbourhood of a solid surface. If formed it will either break up with a large waste of head or, if not sufficiently near the surface for its image to be "bright" it will move forward with little loss of energy. This is apparently what happens at the interface between the "dead" water and the main flow at a sudden enlargement of a pipe. There is in general little loss of head here, as has been very clearly proved in the case of water grooving for pump pistons, with which the leakage has been found to be greater than with a plain piston. Corresponding experiments show that similar results are obtained with steam.

If we take next the case of a fluid flowing past a solid rod, then the positions of the real and imaginary vortices shown in Fig. 3 will be interchanged, the reflections or imaginary vortices will now be inside the rod, and it will be seen that A, which in this way becomes the image of A^1, tends to make A^1 move in the same direction as what in the changed conditions is now the real vortex B^1 would. There is thus no longer any tendency to tear apart any external vortex formed, and turbulence does not then extend far from the solid surface.

This condition of affairs is probably approximated to in steam and water ejectors. The friction causes



a vortex sheet to be set up around the inducing jet, and this sheet moves forward with little resistance, so that it is very difficult to communicate momentum to the surrounding fluid, within any reasonable distance from the nozzle orifice. It is well known that in practice the efficiency of these ejectors as used for clearing air from a surface condenser is extraordinarily small, being in most cases, at any rate, well under 10 per cent.

SWEDISH IRON AND STEEL PRODUCTION, 1922.—The Commercial Secretary at Stockholm has informed the Department of Overseas Trade that the annual report of the Swedish Ironmasters' Association shows that the year 1922 has been a very difficult one for the Swedish iron and steel industries, although on the whole it compared favourably with the previous year. The total production during the year amounted to 259,700 metric tons of pig-iron (about 35·5 per cent. of the 1913 production), against 314,400 tons in 1921; 342,900 tons of ingots and blooms (46·1 per cent. of 1913 production), compared to 236,000 tons in 1921; and 212,700 tons of rolled and wrought iron (corresponding to 61·5 per cent. of the 1913 figure), compared to 127,200 tons in 1921.

TANK WAGONS FOR RUSSIAN RAILWAYS.—The Linke-Hofmann-Lauchhammer Aktien-Gesellschaft is about to complete a very important contract which it undertook in August, 1921, for the delivery to the Russian Government of 1,000 tank wagons for the Russian railways. On January 14, 1922, the first trial wagon was sent to Breslau, and on March 30 the first 50 wagons were sent, shipped by river, via the Elbe to Hamburg. The works operated at high pressure, and in May last attained their greatest output of six tanks, with all equipments, per day. Water, oil, benzine, benzol and other liquid products are to be transported, and the emptying and filling are upon the Nobel system. For the emptying a vacuum pump is fitted. The length of the wagons over the buffers is nearly 33 ft., the length of the tanks 26 ft. 6 in., their internal capacity 1,060 cub. ft., their load about 31·5 tons, and the net weight of the wagons about 20 tons.

BRITISH ENGINEERING STANDARDS ASSOCIATION.—This association has now published the specifications 109—1923, air break knife switches and laminated brush switches for voltages not exceeding 660 volts, and 110—1923, air-break circuit breakers for voltages not exceeding 660 volts. These specifications were first issued in 1921, but it has been found necessary to revise the sections covering tests. As in the first editions they do not include switches or circuit breakers for use with series motors, circuits of high inductance, or traction circuits, all of which may require a higher breaking capacity than is specified therein. A distinction between an isolating switch, a switch and a circuit breaker is laid down as follows: "An isolating switch is intended only for interrupting the circuit when there is no load current. A switch is suitable for breaking a load-current; and a circuit-breaker is suitable for interrupting abnormal conditions such as that of short circuit." A number of terms used in modern switch gear practice have been defined, and a series of standard sizes has been included. Dimensions of back connections and the distance apart of the stud centres of knife switches have been agreed upon so as to secure a reasonable amount of interchangeability without interfering with details of design. Since it is not practicable to take out a complete range of tests on every switch or circuit breaker, the tests have been divided into two categories, *i.e.*, tests which are carried out on every switch or circuit breaker, and those which are carried out only on a switch or circuit breaker of a type. Copies of the specifications above named may be obtained from the offices of the British Engineering Standards Association, 28, Victoria-street, Westminster, S.W. 1, price each 1*s.* net, and 1*s.* 2*d.* post free.

NOTES ON NEW BOOKS.

As a means of expression, drawing in some of its aspects is as useful as writing, telling its tale as swiftly and surely, and often with the added advantage of indicating to the trained eye, accustomed to visualisation, modified and improved methods of accomplishing the purpose of a design. The training that gives deftness of manipulation and accuracy can only be acquired from actual work and constant practice; books, though they repeat only the rules and conventions that have been found suitable for representing structural details or for reading from drawings the information they contain, are however indispensable, and we may give a word of welcome to any treatise that aims at facilitating the progress of the student and making more intelligible the manner and purpose of projection. This is the object that Mr. L. E. Cutter, Assistant Engineering Professor in the Stanford University, California, has in view in preparing the work on "*Descriptive Geometry*" (McGraw-Hill Book Company, London and New York; price 12*s.* 6*d.* net), and very satisfactorily has he accomplished it. In opposition to the usual method of rotation, in which the object is virtually rotated about an axis parallel or perpendicular to a projection plane, and only two such planes are used; the author is of opinion that clearness and freedom from confusion are better secured by adopting the so-called method of choosing new projection planes, that is, the object to be drawn is regarded as stationary and surrounded by projection planes, either parallel or perpendicular to certain lines of the object, on which the projections are to be made. The same general principles are used in both cases, and the mental discipline is the same, convenience is the only guide to selection. These principles are very simple and no previous knowledge of descriptive, or of ordinary plane geometry, is required to enable the student to follow the construction of the various problems, that pursue the ordinary course, embracing the projection of points, lines, angles, planes, surfaces, intersections, &c., the whole illuminated by practical experience gained in actual contact with classes of engineering students. The insistence on the construction of models to illustrate certain fundamental problems seems very appropriate, and the hints given for securing mechanical accuracy are helpful to the novice, the author remarking with more than a little truth, that by the time the pupil has got his model completed "so it accurately fits together, he will have learnt considerable about projection." Two features somewhat off the ordinary path strike us as admirably adapted for widening the outlook and illustrating the practical applications of projection. One is the adaptation of the general principles to mining work, with the object of showing that the method can be used for locating shafts and tunnels to reach ore veins or rock strata, concerning which certain data can be gathered. The other is the application to crystallography and the drawing of crystals from given dihedral angles. Such problems may not come before the engineer, but considering how largely such problems occupy the physicist and mineralogist, the subject might have been pursued further than a single example. An interesting and suggestive chapter is given on Axometric, Isometric and oblique projection, and we could have wished the remarks on Warped Surfaces had been extended.

In glancing at recent publications of technical and scientific books, brought out in Central Europe, one must not forget that the student of a college or of continuation classes over there may find it very hard at present to procure himself even the indispensable amount of food, and that he has very little to spare for books. One rather wonders at the number of new books still coming out. Some of these, however, do not disguise the fact that they are especially compiled to meet the exceptional conditions, and that they are practically extracts from larger volumes. Thus the "*Wechselstromerzeuger*" (alternating current generators) of Professor Franz Sallinger, of Esslingen, one of the new books of the Sammlung Göschen (Berlin, Vereinigung wissenschaftlicher Verleger; price 1*s.* in England) acknowledges that he is largely indebted for figures and text to Professor Pichelmayer's larger books. The treatment of the subject, the vector diagrams, exposition of parallel working, &c., will, we think, be found profitable to the student. Mr. Alfred Kirschke, of Kiel, has no need to speak of particular indebtedness; but he has certainly not been less successful with his "*Gasmaschinen und Oelmaschinen* (also Sammlung Göschen; price 1*s.* 6*d.*). Professor H. Haberstroh, of Holzminden, deals in the three volumes of his "*Baustoffkunde*" (*ibid.*, 1*s.* each volume) with building materials (stone, mortar, wood, iron) in general and with the special materials for house construction, and for subterranean and marine construction; due attention is paid to "substitutes" and to heat insulation, in view of the high prices of the

70-TON PORTABLE STEAM DERRICK CRANE.

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(*For Description, see Page* 426.)

FIG. 1.

higher classes of fuel. Much—too much possibly—is also made of peat utilisation.

British manufacturers are now showing a great change of outlook regarding the value of scientific investigation. Laboratories are being erected in great number, either as parts of the equipment of works or for the prosecution of test work for an association of manufacturers. These are frequently most expensive buildings and very elaborately equipped. It must not be forgotten, however, that the value of the work done in such institutions can only be measured in terms of the capacity of the staff. A recent book on "*A Tested Method of Laboratory Organisation*," by Seymour Pile and Reginald Johnston, published by H. F. and G. Witherby, London, at 7*s.* 6*d.* net, is interesting as it shows methods of classifying test results and other matter in a laboratory. The outlook of the authors on personnel is not common. After describing the peculiar combinations of characteristics for a chief in a works laboratory, they suggest that the staff should be selected by the chief. Few men selected for the position of leadership in a works laboratory would have the same views as the authors, who believe that an efficient staff can be trained in the laboratory without any other preliminary preparation than is implied in a secondary school education. Men vary very much and many efficient workers could be obtained in that way; but it would entail less trouble and less expense if they received a more adequate scientific training before they started on their laboratory careers. The authors think that the junior staff of a laboratory should not be encouraged to read science in their spare time. They consider that scientific men, as a rule, are not good organisers. They must have had a strange experience when they dismiss in that fashion, the capacity of men who devote their lives to bringing order out of chaos. The essential thing in all scientific work is order, and if the old ideas that scientists are all impractical people could be removed from the minds of business men they might discover among them organisers of the greatest ability.

While it is probable that of the large number of persons who now make use of wireless-receiving apparatus only a very few are capable of carrying out experimental work that is likely to advance the subject to any extent, there must be many who would be glad to make some experiments with a view to improving the efficiency of their own apparatus. Such persons will certainly find much to interest them in "*The Amateurs' Book of Wireless Circuits*," which has been prepared by Mr. F. H. Haynes, and is published by the Wireless Press, Limited, 12–13, Henrietta-street, Covent Garden, W.C. 2. This book contains approximately 100 large-scale diagrams of receiving circuits of all kinds arranged progressively from the simplest crystal set to elaborate multi-valve circuits with super-regeneration. The diagrams are exceptionally clear and as the values of condenser capacities, &c., are given with a few notes on each of the circuits, an amateur with but little experience should have no difficulty in making up any one of them; he would also be able to check the connections of his own apparatus from the diagrams, if doubtful of their accuracy. In addition to receiving apparatus, diagrams of connections are given for transmitting sets, wave-meters, accumulator charging apparatus, &c., which will be of service to the more advanced amateur. It would, we understand, be necessary for anyone before experimenting with different circuits to possess an experimenter's licence from the Postmaster-General. For the sake of beginners it would perhaps be as well to make this clear, and as apparently several of the circuits shown do not comply with Post Office requirements for reception on broadcasting wave-lengths, we suggest that special warning of this should be given where necessary. On the whole, however, the book will be extremely helpful to the class of person for whom it is intended, and its low price of 2*s.* 6*d.* net should lead to extensive sales.

Short treatises on special branches of engineering science are not without reason regarded with a certain amount of distrust. Common-place talk predominates too strongly in some recent technical text books, whether avowedly of the popular type or intended for the student and young engineer. The name of the author is not always a guarantee of merit and value. Such prejudices would be unjustified in the case of the "*Theorie und Bau der Dampfturbinen*," by D. Ing. Herbert Melan (Leipzig-Wien: Waldheim-Eberle; price 4 marks plus 500 per cent.). Dr. Melan, who is lecturer at the German Technical High School of Prague, makes an earnest and on the whole successful and commendable attempt at explaining the theory and construction of steam turbines in a duodecimo volume of 288 pages, illustrated by 163 diagrams and curves. Starting from the thermodynamics of water-vapour, in which he makes use of Callendar's tables, he deals with the steam flow through buckets and nozzles, with the calculation and construction of these parts, with rotors, shafts, couplings, labyrinths and bearings, with valves and gearing, and finally with different types of turbines and their applications. That most of his illustrations exemplify machines of Continental firms, some of which had supplied him with special information, would hardly call for comment. The student of engineering might, however, look for more prominent general definitions, especially as there is no index. The treatment of the subject does not provide easy reading.

About 80 miles south-west of Berlin, in the Bitterfeld area, are large deposits of lignite which were developed during the war to provide electrical energy for the artificial fixation of atmospheric nitrogen, and for the needs of the population of the capital. A power station was built during 1915 on the lignite fields at Golpa, and a general description of this station is the subject-matter of "*A* 130,000-*Kw. Power Station*," by Dr. G. Klingenberg (London: Crosby Lockwood and Son, 1922: price 21*s.* net). A perusal of the book leads to the conclusion that British engineers have little or nothing to learn from German ones in connection with either the lay-out of large power stations or with the design of their machinery. The boilers in the Golpa Station have a heating surface of only about 5,500 sq. ft., and work at a pressure of 192 lb. per square inch. Natural draught only is used, nine brick chimneys, each about 200 ft. high, being employed to deal with the products of combustion. There are eight A.E.G. turbine generators, each rated at 22,000 k.v.a., supplying current at 50 cycles and 6,600 volts, the speed of the machines being 1,500 r.p.m. The condensing water is cooled by 11 cooling towers, each 115 ft. high and covering a ground area of 75 ft. by 105 ft. These are the largest cooling towers in Germany. We find nothing in the station which is in advance of British practice, and a great deal which belongs to a past era. The designer might even learn a lot from some of our older stations. The book is a translation from the German, and is printed in Germany throughout, including even the title page. It comprises only 154 pages and three folding plates, so that the price at which it is sold in England should leave a handsome margin, in marks, to the producers. There appear to be no figures anywhere in the book giving the economy of the station or the efficiency of its component parts, but there is no reason to believe that they are in any way extraordinary.

Although there has been no great scientific development in wireless telegraphy or telephony during the past year, the advent of broadcasting in this country has led to a remarkable development in the industry on the amateur and experimental side. Steady progress is, however, being made in connection with long-distance transmission, and the construction of high-powered stations for this class of work is under consideration, both in this country and abroad. To keep pace with modern requirements, "*The Year Book of Wireless Telegraphy and Telephony*, which has been for many years the *vade mecum* of all users of wireless communication, has been largely remodelled, and many new features have been included in the latest edition which has just made its appearance. It is published by the Wireless Press, Limited, 12 and 13, Henrietta-street, Covent Garden, W.C. 2. In addition to the usual features, which include a record of developments in various countries, reprints of the national and international laws and regulations relating to wireless telegraphy, and a directory of the wireless stations of the world, the present edition contains a new section in which the positions of all known land stations are marked on a series of maps. Another additional section relates to direction finding, which is rapidly becoming of importance in connection with aerial and marine navigation. Special articles by experts on automatic reception, multiple aerials and the design and manufacture of valves are included, with a variety of other useful and interesting material. The amateur and experimental section has been extended to bring it into line with recent developments in this branch of wireless activities, and includes a *résumé* of progress, a directory of wireless stations, a list of call signs of experimental stations and a list of times of regular transmissions suitable for amateur reception. A special edition of the year book, bound in paper covers, and sold at the price of 6*s.* net, is now issued for amateurs who, by this time, we suppose, must greatly outnumber the professional users of wireless apparatus.

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Fig. 2. WHARF LAY-OUT SHOWING POSITION OF DERRICK CRANE.

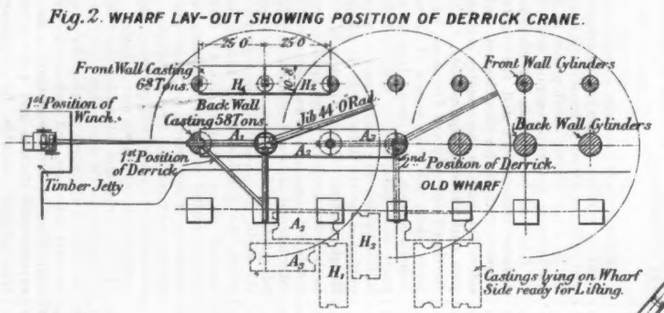


Fig. 3.

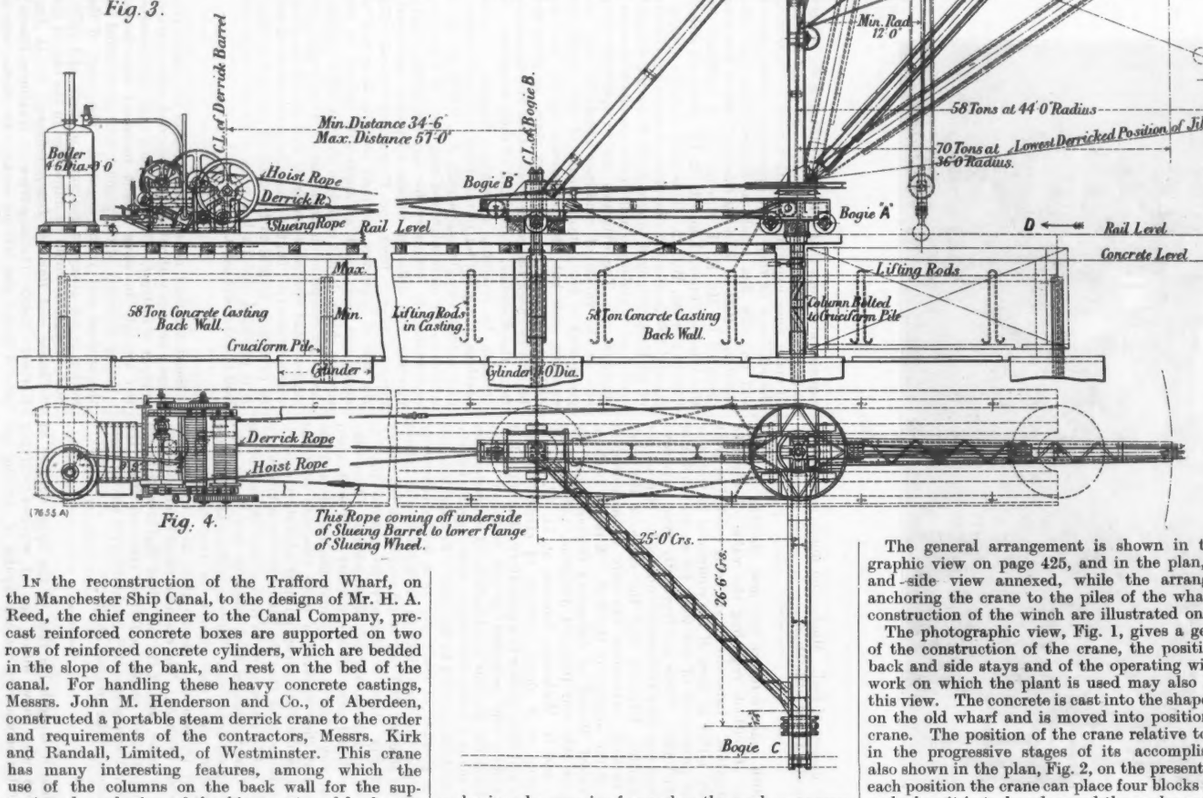
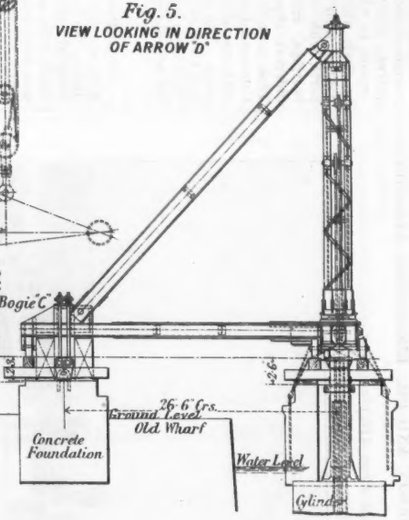


Fig. 4.

Fig. 5. VIEW LOOKING IN DIRECTION OF ARROW "D"



In the reconstruction of the Trafford Wharf, on the Manchester Ship Canal, to the designs of Mr. H. A. Reed, the chief engineer to the Canal Company, pre-cast reinforced concrete boxes are supported on two rows of reinforced concrete cylinders, which are bedded in the slope of the bank, and rest on the bed of the canal. For handling these heavy concrete castings, Messrs. John M. Henderson and Co., of Aberdeen, constructed a portable steam derrick crane to the order and requirements of the contractors, Messrs. Kirk and Randall, Limited, of Westminster. This crane has many interesting features, among which the use of the columns on the back wall for the support and anchoring of the king post and back stay when in use, and the portability due to being wheeled on bogies when moving forward as the work progresses are perhaps the most out-standing.

The general arrangement is shown in the photographic view on page 425, and in the plan, elevation and side view annexed, while the arrangement of anchoring the crane to the piles of the wharf and the construction of the winch are illustrated on page 427.

The photographic view, Fig. 1, gives a general idea of the construction of the crane, the positions of the back and side stays and of the operating winch. The work on which the plant is used may also be seen in this view. The concrete is cast into the shapes required on the old wharf and is moved into position with the crane. The position of the crane relative to the work in the progressive stages of its accomplishment, is also shown in the plan, Fig. 2, on the present page. In each position the crane can place four blocks in position and when it is to be advanced the anchorage construction for the king post and back stay, which will be described later, are removed and secured to another set of piles for subsequent work.

The crane was designed to deal with the full load of 70 tons at a radius of 36 ft., and with 58 tons at 44 ft. radius, and to derrick inwards to a minimum radius of 12 ft. The king post, back stay and jib are formed of rolled steel sections, strongly reinforced with plates and suitably braced, as is shown in Figs. 3, 4, 5, annexed. The wheels of the bogies have wide flat treads and are of 2 ft. diameter. These run on a track of steel channels laid on timber beams.

When handling the load, the crane is packed up to take the pressure off the wheels and the bogie is supported on a column constructed with heavy plates and angles. A cast steel circular base is fitted to the bottom of the column for seating on the top of the cylindrical concrete caisson and its position is shown under the king post in Fig. 3. This column encircles, and is securely bolted to, the cruciform pile which projects through the caisson. The back stay bogie is also anchored to a cruciform pile and the side one to a concrete foundation. Details of the encircling column used for the back stay are shown in Figs. 6 and 7 on the opposite page, the construction for the king post

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Fig. 8.

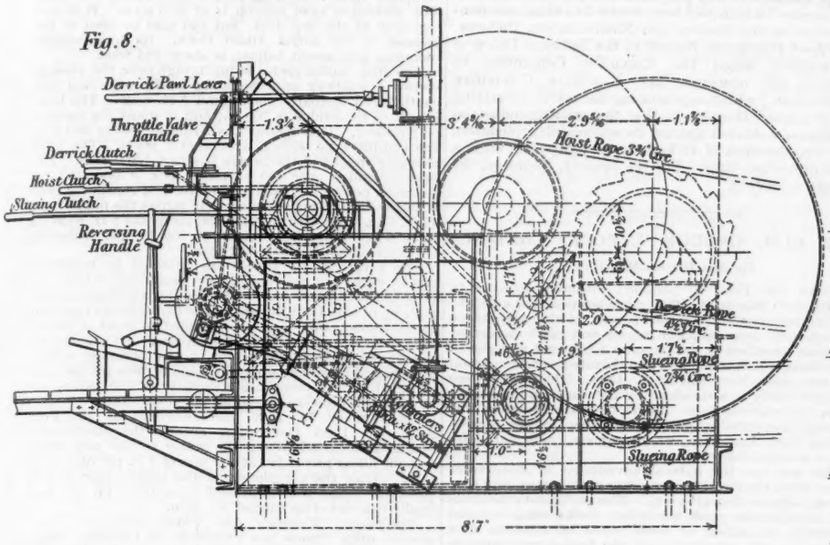


Fig. 6.

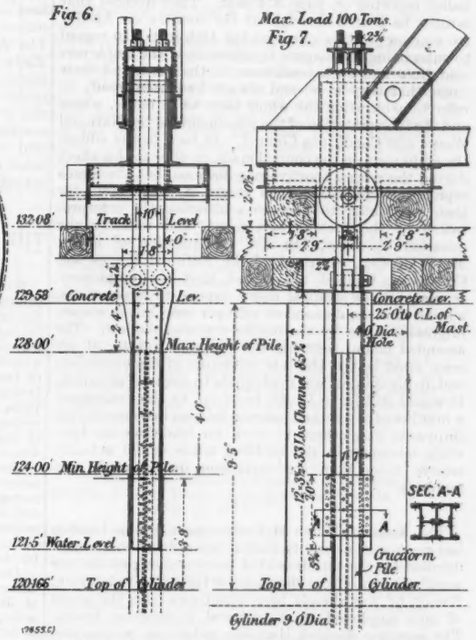


Fig. 7.

Fig. 9.

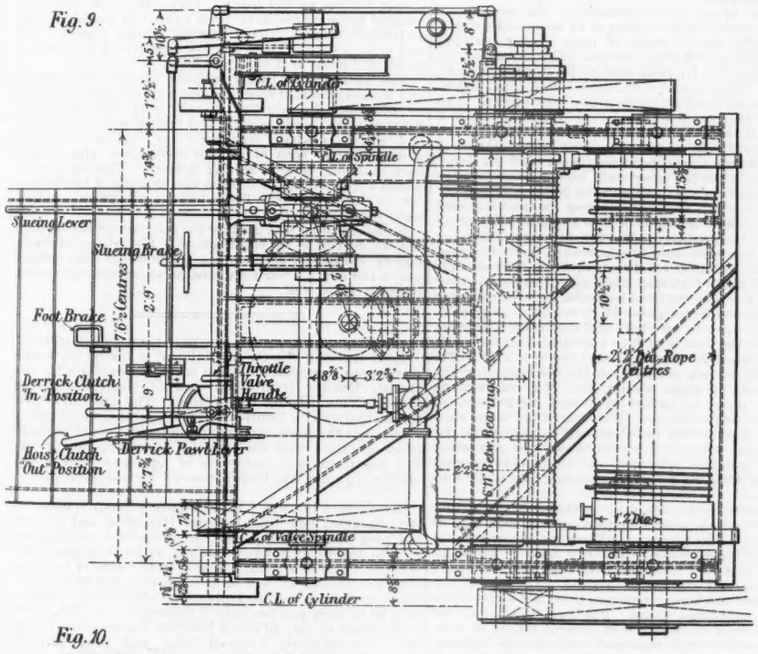
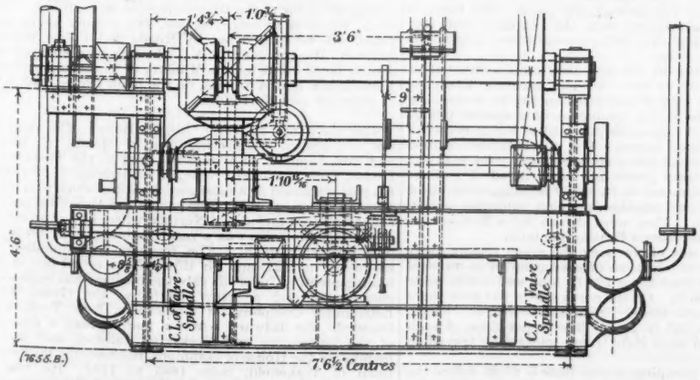


Fig. 10.



one being somewhat different, especially in that it is provided at the foot with a circular base. A drilling jig was designed and constructed for use in drilling the piles in the correct positions for the bolts.

The king post turns on a race of 20 rollers, made of 3 per cent. nickel-chrome steel, situated in a retaining ring. A bull wheel, 9 ft. diameter, is used to slue the king post and is formed of steel sections. The load is carried on nine parts of wire rope, 3¾ in. circumference, the last of which is led back to the hoisting drum of the winch. A ball-bearing swivel carries the shackle of the hoisting block. The jib is supported by steel tie rods and nine parts of wire rope, 4½ in. circumference, the free end being taken back to the derricking drum. All the principal castings of the structure, are of steel manufactured by the electric process in the builder's foundry. The sleepers and bogies are built up of steel sections and plates.

The winch gearing and engines are mounted on a frame with side cheeks constructed of mild steel plates, strongly reinforced with angles. The cheeks are connected together by sections and braced. All control levers are brought to a platform for easy operation by the control man. The boiler is of the vertical cross-tube type; it is 4 ft. 6 in. diameter and 9 ft. high, and constructed for a working pressure of 80 lb. per square inch. The steam which it generates is used in double-cylinder engines of 8-in. bore and 12-in. stroke. Link motion is provided to control the working and reversal of the engines to meet all requirements. The hoisting speed obtainable is from 3 ft. to 4 ft. per minute, and the slueing speed 50 ft. per minute at the jib head.

The complete winch equipment can be skidded forward to follow the crane as the work proceeds. The hoisting and derricking motions are combined on the well-known Scotch derrick crane principle, so that when luffing, the load will travel along what is approximately a horizontal path. The arrangement of the winch is shown in plan, elevation and side view in Figs. 8, 9 and 10, annexed. Pawls engage in the teeth of rachet wheels on the derricking drums, and the lever for raising them is interlocked with the lever controlling the clutch which couples the hoisting and derricking drum together, so that the pawls cannot be lifted until the clutch is engaged. Both of the drums, hoisting and derricking, have helical grooves cut on them for the accommodation of the ropes. Two drums for the slueing ropes are situated on each side of the winch and are operated through reversible friction cones. A 2¾ in. circumference wire rope is led from each drum to the bull wheel on the king post, round which it is wound several times before being secured.

COAL-MINING ACCIDENTS IN GREAT BRITAIN.—The statistician of the United States Bureau of Mines, Mr. W. W. Adams, recently gave comparative figures of the accidents in British and American mines which show the British accident rate to be between one-third and one-fourth of that of America. Among the factors to which this lower rate may be attributed are, the experience possessed by the British miners, the use of a common language, the less extensive use of machinery, greater caution in timbering at the working face, shale dusting and the slower speed at which the men work, this last factor being reflected in the fact that the average output per man here is only one-third of that in America.

INDUSTRIAL NOTES.

THE building trade employers met in London last week to consider the situation arising from the men's ballot reported on page 374 *ante*. They decided that notices be posted throughout the country on April 7 (to-morrow) to take effect on the 14th inst. In regard to submitting the dispute to arbitration, the employers said they had such confidence in the justice of their cause that they were, and always had been, ready to refer to arbitration the whole issue as to hours, wages and the interpretation of the agreements of the National Wages and Conditions Council. In fact, it was added, the employers on the council made an offer to this effect during the recent abortive negotiations, but the men's representatives declined to accept it. The men, for their part, offer to refer to arbitration the interpretation of the present agreement, and possibly the question of wages, but not the question of hours. Mr. S. Easten, chairman of the National Wages and Conditions Council has stated that the employers' representatives strained every avenue to avoid strife, adding that the demand of a 20 per cent. cut in wages, originally made by the employers, was modest. The amended claim, reducing the proposed cut to 10 per cent. must be the absolute minimum of the employers and, in his opinion, was inadequate to meet the situation. It would still leave 1*s.* 6*d.* per hour to the craftsmen, a number of whom had entered into an agreement with shipyards and others to work for less than 1*s.* 1½*d.*, while labourers in the building trade would actually receive more than the craftsmen in shipyards and factories.

The National Union of Railwaymen met in London last week with a view to discuss the railway companies' demand for the withdrawal of the remaining 6*s.* 6*d.* per week war bonus from the wages of the railway shopmen. The 6*s.* 6*d.* has already been withdrawn from the wages of men employed in the general engineering trades. The meeting decided that the reduction in question should be resisted in the case of the railway shopmen, and in the event of the railway companies attempting to enforce it, the Executive Committee were instructed to call a national all-grades strike of railwaymen. Up to the present, the wages of the railway shopmen have only been reduced by 10*s.* of the 16*s.* 6*d.* war bonus. The further reduction has been under consideration since the commencement of January last, as we reported at the time.

The Council of the Cleveland Ironstone Miners' Association have accepted the mine owners' proposal to revert to the 8-hour day, in the hope that the change will restore the industry to a more prosperous state. The council reserved the right to raise the question again at the end of twelve months. The miners recently voted against the proposals of the owners, but the latter intimated that unless the concession was made some of the mines would have to be closed, adding that if the men accepted the 8-hour day it would be possible to open more mines. There is to be an increase in the wages of the lower-paid datal men; new base rates and a sliding scale are also to be considered. The change involves an addition to the working day of about half-an-hour, as the present 7-hour day excludes the time occupied by the miners in travelling from bank to face, whereas the 8-hour day is from bank to bank.

Owing to the depressed conditions in the farming industries a number of farmers in the Midlands have been compelled to reduce their farm labourers' wages to 5½*d.* per hour and to ask the labourers for a working week of 54 hours instead of 50. The main trouble is in Norfolk, where the wage was 25*s.* per week for 50 hours, or 6*d.* per hour. For a full working week of 54 hours, 5½*d.* per hour would give 24*s.* 9*d.* But the difficulty is that farmers cannot guarantee a full working week. In some instances, therefore, they cannot guarantee this latter weekly wage, let alone one of 30*s.* which has been mentioned in the discussions. Another proposal is to the effect that the labourers be paid at the rate of 24*s.* per week for 50 hours, 25*s.* for 52 and 26*s.* for 54 hours. The dispute has now lasted about a fortnight and no solution has as yet been forthcoming.

The report in our last issue to the effect that the Welsh miners' strikes at several collieries, in the matter of rival union membership, was coming to an end, was a premature report. Stoppages of collieries in the Rhondda Valley and rumours of stoppages of others in other parts of South Wales are now announced, still because the Miners' Federation leaders wish to eliminate membership of other unions. The strike is virtually one between rival unions, to the detriment of the miners. It is stated, however, that the Tredegar miners have rejected the recommendation of their executive to strike on the trade union question, and have passed a resolution deploring the attitude of the executive.

In a preceding issue (page 171 *ante*) we referred to the proposed one day per week strike scheme as "the best means" which had been devised to eliminate non-unionism on the London and North-Eastern Railway. The West Hartlepool Branch of the National Union of Railwaymen asked the Executive Committee to sanction the measure. The Executive Committee replied that "whilst appreciating the spirit underlying the proposal" they found that the existing industrial conditions militated against its successful application, and consideration of it had to be postponed until a more opportune time. For the present, therefore, the scheme is shelved.

THE KING GEORGE V. DOCK, LONDON.*

By ASA BINNS, M.Inst.C.E.

WHEN the Port of London Authority came into existence on March 31, 1909, consideration was given to the improvement of the port; and, of the new works immediately approved, the largest and most important was that described in this paper. A contract was placed with Messrs. S. Pearson and Son, Limited, for completion in four years from August 1, 1912. The works were brought nearly to a standstill by the war, and in August, 1918, in order to meet urgent national demands, the contract was terminated by arrangement at the request of the Port Authority, who completed the works by direct administration.

The site has the natural advantages of deep-water access from the river, good railway connections, and easy cartage distance from the city. The geological conditions are exceptionally good, the heavy works being founded generally on ballast or chalk; the excavations were mainly in soft alluvium, and the ballast was suitable for making concrete.

Design and Method of Construction.—The new works comprise a wet dock with an area of 64 acres and a depth of 38 ft., with over 2 miles of quay giving berthing accommodation for 14 large vessels. The entrance lock is 800 ft. long, 100 ft. wide and 45 ft. deep at Trinity high water. There is also a dry dock 750 ft. long, 100 ft. wide, with a depth of 35 ft. over the keel blocks. The new dock is connected to the Royal Albert Dock by a passage 100 ft. wide with a depth of 34 ft.

On the south side of the wet dock seven jetties of reinforced concrete are provided, each 520 ft. long. They are parallel to the quay wall, with a barge passage 32 ft. wide between the quay and the jetties. The quay walls have a vertical face, a projecting toe, and a sloped foundation. The concrete is of 8 to 1 quality, excepting a 6-in. face of 4 to 1 quality. The top alluvium overlaying the ballast was excavated by Lubecker land dredgers, and below the ballast-level the excavations for the walls were carried out in timbered trenches. The ballast over the dock bottom was removed by grabs. In the entrance lock are three sets of lock gates which are interchangeable. The levelling culverts are short and finished in concrete. The invert of the lock is of 6 to 1 quality, and the walls are of 8 to 1 quality. Passing under the lock with shafts on each side are six subways, 6 ft. diameter, for the accommodation of pipes, cables, &c. The excavations for the lock down to ballast-level were carried out by grabs and a steam navvy. The side walls were then constructed in timbered trenches, and subsequently the excavation and concreting of the invert was proceeded with. Two gantries spanning the lock and carrying 5-ton cranes were used for constructing the walls and invert.

The entrance to the dry dock is closed by a floating caisson. There is a short filling culvert on each side of the entrance. The drainage culvert to the pumps is short and of large section. The dry dock is generally constructed in 8 to 1 concrete, with sills, quoins, altars, shore stones, and coping of granite. To relieve the pressure under the floor, vents are provided at intervals just above the bilge altars. The keel blocks are of cast-iron finished in timber with a total height of 4 ft. The dry dock is well equipped with cranes, railway connections, and compressed air plant. To form a passage to Royal Albert Dock, the old dock wall was removed in the dry after being enclosed by a single-skin pile dam, 400 ft. long.

The seven jetties in the wet dock are constructed of reinforced concrete on the Considère system. The piles are octagonal in section and measure 18¼ in. across the flats. They were driven by means of a special piling-plant carried on a bogie, the pile leaders being swivelled to give the required batter. The pile monkey weighed 83 cwt. A timber gangway connects each jetty with the quay. The entrance jetties are constructed of timber. The pitch-pine piles are 65 ft. to 70 ft. long, built up of whole timbers bolted together, giving a minimum section of 28-in. by 14-in. They were driven by a McKiernan-Terry pile hammer from a floating pontoon.

On the south side of the dock the seven transit sheds are of the single-storey type of corrugated iron on steel framework, each shed being 528 ft. long and 120 ft. wide in two spans of 60 ft. On the north side of the dock there are three double-storey reinforced-concrete sheds, approximately 1,100 ft. long. The upper floor of each shed is equipped with eight 1-ton underhung travelling electric cranes.

The dry-dock pumping station floor is 27 ft. below the dock coping. The main pumps are in duplicate, and are designed to empty the dry dock in 3 hours when working together. The steel lock gates are of the double-skin type. Six air chambers to give buoyancy, are formed in each leaf. They are sheathed with timber on both sides, and are operated by direct-acting hydraulic rams. Each leaf, complete with sheathing, &c., weighs about 350 tons. The reversible steel caisson is of ship form. It is used regularly at the dry dock, but can also be used at the passage to the Royal Albert Dock. Its total weight, including permanent ballast, is about 965 tons.

The steel lattice-girder swing bridge over the passage carries a roadway approximately 20 ft. wide and two cantilevered footpaths each about 5 ft. wide. The total length of the bridge is 200 ft., and it spans the passage on the skew. It is operated by hydraulic power and is of the end-lift type with a fixed centre pivot. The total swinging weight of the bridge is about 1,800 tons. The bascule bridge over the entrance lock is operated by electrical power, and is of the double-leaf cantilever type with steel lattice main girders. It carries the public road 17 ft. 6 in. wide with cantilevered footpaths 6 ft. wide on each side. The total weight of the bridge, including counterweights, is about 742 tons.

The penstocks for sluices are operated by hydraulic power excepting the emergency penstocks, which are provided with hand gear. The paddles are of greenheart built up of logs 11 in. square. The capstans are operated by hydraulic power and are designed to exert a pull of 10 tons at a speed of 80 ft. per minute. To supplement the supply of hydraulic power, a new pumping station was erected in which two multi-stage turbine pumps were installed. Each pump has a capacity of 400 gallons per minute at a pressure of 800 lb. per square inch.

On January 12, 1920, the chairman of the Port Authority, Lord Devonport, opened the electrically-operated sluice admitting the water to the new dock, and the filling proceeded at the rate of 1 ft. per day up to O.D. After the completion of the middle pair of lock gates the filling was continued from June 24, and was finally completed on August 12, 1920.

Equipment, Materials and Plant.—Sixty-six 3-ton electric quay cranes are provided for handling cargo. In addition there are 14 light runabout 15-cwt. electric cranes for use in the sheds. Five additional six-wheel coupled locomotives have been provided, together with additional wagons. Nine electric trucks handle road and quay traffic. These have a capacity of 2 tons at a speed of 5 miles or 6 miles per hour.

The materials used were generally of excellent quality, and British standard specifications were adopted as widely as possible. In addition to the soft alluvium over 1,000,000 cub. yards of sand and ballast were excavated, and about one-half was used for making concrete. About 100,000 tons of cement were used, the greater portion being of slow-setting quality. Careful experiments were made to secure the best grading of the ballast for making concrete. The whole of the granite ashlar came from Cornwall.

Excellent plant was used by the contractors throughout the whole period of construction. Electric power was largely utilised for all purposes. The works were carried out in the dry. Their total cost as at present authorised is about 4,130,000*l.*

* Abstract of a paper to be read before the Institution of Civil Engineers on Tuesday, April 10, 1923.

SEA TRANSPORT AT THE BRITISH EMPIRE EXHIBITION.—Lord Kylsant (Sir Owen Philipps) is taking an active part in the organisation of sea transport exhibits for the British Empire Exhibition, and is chairman of the Special Committee for this section. The space available for sea transport is limited, and the exhibition authorities desire that the reservations and allotment should be made in co-operation with the principal steamship companies. For this purpose a conference of representatives of the chief companies has been convened for the 10th inst.

MIDDLESEX COUNTY UNEMPLOYMENT ROAD SCHEME.—An important new road between Hounslow and Harrow has been planned and passed for immediate construction by the Middlesex County Council as an unemployment scheme. The new road, which is to be made of concrete with asphalt carpet, will be 3½ miles long and 60 ft. wide. There will be a granite kerbed and channelled carriage-way 40 ft. wide and two gravel footways each 10 ft. wide. It will start at the old Great Western Railway iron bridge at Uxbridge-road, Hanwell, and will pass through Greenford as far as the District Station at Sudbury. The work, which is to cost 160,555*l.* and occupy about two years, will be carried out by Roads and Public Works, Limited, Westminster, S.W., who are also engaged on similar large works for the Ministry of Transport between Farningham and Wrotham, on the main Dover-road, and at Dartford and Northfleet.

THE LATE SIR EDWARD GREEN, BART.—The head of the well-known engineering firm of Messrs. E. Green and Son, Limited, of Wakefield, died at the Treasurer's House, York, on Good Friday, at the ripe age of 92 years. He was possessed of a most genial nature which won from him the affections of his workpeople and also of his native county of York and also of Norfolk, where he had an estate at Snettisham. He was a rare combination of business man and sportsman. The business was founded by his father in 1821, and Sir Edward succeeded him in its management. Under his care the business has expanded enormously and a sister company, the Green Fuel Economiser Company, of Matteawan, New York, was founded. Sir Edward was for many years a director of the Lancashire and Yorkshire Railway, and was a member of the House of Commons, representing his native town of Wakefield, from 1885 to 1892. He was a member of the Institution of Mechanical Engineers and of the Iron and Steel Institute. He was created a baronet in 1886, and is succeeded by his elder son, Mr. Edward Lycett Green.

SOCIETY OF GLASS TECHNOLOGY.

THE President, Professor W. E. S. Turner, D.Sc., occupied the chair at the meeting of the Society of Glass Technology at the University, Birmingham, on Wednesday, March 21. The papers presented were all contributions from the Department of Glass Technology, the University, Sheffield.

The first one, entitled "*A Rapid Method of Testing the Durability of Glassware*," by Mr. H. S. Blackmore, Miss Violet Dimbleby, and Professor W. E. S. Turner, was read by Miss V. Dimbleby, who was thus the first lady to read a paper before the society. The paper presented an account of a simple and rapid method for determining whether a sample of glass would withstand weathering sufficiently to enable it to fulfil certain purposes. The test depends on the fact that when a very dilute solution of one part in 1,000 of the alkaloid narcotine hydrochloride, is heated to boiling point inside a glass vessel, the alkaloid is thrown out of solution, and can be seen as a fine precipitate if the glass is of poor quality. If this occurred at the end of 10 minutes' heating, the glass was to be condemned; if within 20 minutes, the glass, although better, was still unsatisfactory. Good glasses ought to show no sign of deposit when heated at the boiling point for an hour. It was pointed out that this test differed from all the others previously devised and used in that it required no special chemical knowledge, could be carried out with very simple apparatus, and therefore was a test which could be applied in any factory. The test was shown to be thoroughly satisfactory by a large number of trials on all kinds of glassware.

The two other papers contributed were "*The Corrosion of Fireclay Refractory Material by Glass and Glass-making Materials*," by Mr. Donald Turner and Professor W. E. S. Turner, and "*The Effect of Saltcake in Corroding Fireclay Materials*," by Miss Edith M. Firth, Mr. F. W. Hodkin and Professor W. E. S. Turner. These two papers were taken together and presented by Professor Turner, who detailed experimental evidence showing that in glass melting the corrosion of the pots or of the tank blocks was most severe during the early stages of the melting of the batch. The corrosion due to the glass itself was proved to be very much less. Of the glass-making materials, sodium nitrate, potassium nitrate, and borax were particularly corrosive. Resistance to corrosion could be improved by firing the pots or blocks at 1,400 deg. before the charge of batch was inserted. At temperatures round about 800 deg. or 900 deg. C. saltcake was not nearly so corrosive as soda ash. At the temperature of the melting furnace, however, it appeared to be more corrosive, and it was demonstrated by a series of experiments that as the proportion of saltcake increased, so did the extensiveness of corrosion, even in batches in which coke, as a reducing agent for the saltcake, was present throughout.

During the forenoon a party of members visited the Longbridge Works of Messrs. Austin Motor Company, Limited, Northfield.

SUGGESTED SPECIFICATION FOR PERMANENT MAGNET STEEL.

To the Editor of Engineering.

SIR,—Professor Crapper's letter in ENGINEERING of March 16, page 329, raises so many points of great interest to all users of permanent magnets, that I must ask permission to make some amplification of my previous letter, and to state more definitely my views in connection with the subject.

Professor Crapper's letter is chiefly concerned with the importance of the slope of the BH curve to the user of the magnet, and he suggests that this may have a bearing on the permanence of the magnet as well as upon the factor, which he terms the magnetic elasticity. I am afraid it must be admitted that permanence *per se* is a thing about which little is understood, and still less known, and the reason for this is, I think, that it is very difficult to separate the diminution in flux which represents the true permanence from that which is due to the influence of demagnetising forces. If we take a piece of steel forming a closed magnetic circuit, and magnetise it, we shall, after removal of the magnetising force, be left with that steel carrying a flux equivalent to the remanence of the material. If now we apply a demagnetising force, either by means of an electric current or by introducing a gap in the circuit, we shall reduce the flux density to some lower value. The amount of reduction which occurs is in no way a measure of the true permanence of the magnet, but is simply a function of the coercive force. If we now take the magnet in this condition and subject it to vibration or to small cyclic changes of temperature, insufficient in magnitude to cause any change in the metallurgical structure of the material, or if we leave the magnet standing for many months, or years, we shall probably obtain a further slight reduction in flux density, and this additional reduction is a function of the true permanence, or stability of the material under the given conditions of demagnetising force. I am afraid our present knowledge of the true permanence is too scanty to enable us to express accurately its relation to the other properties of a magnet, much less to lay it down in a specification intended for magnet uses.

As regards the phenomenon of magnetic elasticity or the amount of flux which reappears when a given demagnetising force is removed, it is perfectly true that this is of some importance when a magnet is used in an apparatus such as a magneto, where the demagnetising force undergoes cyclic variations. At the same time taking magnets as they stand at present the value of this "recovered flux" expressed as a fraction of the flux density at the point of BH max. varies so little between different steels that it may for practical purposes be neglected, particularly when we remember that the associated cyclic change in the magnet itself is in the case of the magneto so damped by the presence of eddy currents in the steel as to be of little or no value.

What the user of a permanent magnet requires to know is, firstly, how much energy he can obtain in his external circuit for a given outlay of money, and secondly, what will be the form which the magnet must take, *i.e*, must it be long and thin, or short and fat. The value of $\beta\phi$ max., and the value of H at which this occurs, will put him in the possession of all this information.

Professor Crapper will probably argue that not only will the user require this information, but that he will also want to know what further flux reduction will ensue should the magnet be submitted to a momentary overload, *i.e*,. he will want to know the shape of the BH curve at the point of $\beta\phi$ max. What he really requires, however, is the ratio of percentage decrease in B to percentage increase in H, or in symbols the value of—

$$\frac{d\,B}{B} \div \frac{d\,H}{H}$$ at the point in question.

The value of this quality for all present-day magnet steels which have been properly hardened is to all intents and purposes a constant, or at all events one may say with certainty that any error in composition or heat treatment, sufficient seriously to affect this ratio, would at once cause the $\beta\phi$ max. to be lessened to such an extent as to cause rejection of the steel.

In conclusion, while I would not wish Professor Crapper to think I am unduly critical of his efforts, I would plead that in the present state of our knowledge of permanent magnets any specification should be confined to laying down the value of $\beta\phi$ max. with its associated value of H, the tolerance allowed being such as to ensure that all magnets complying with the specification give equal results in a properly designed apparatus, and that the other questions which he has raised should be left for the present as subjects for the research which has long been sorely needed, but has yet to be carried out.

Yours faithfully,
G. A. WATSON.

The M-L Magneto Synd., Limited, Victoria Works, Coventry, March 30, 1923.

"INVENTION AND REWARD."

To the Editor of Engineering.

SIR,—Your leading article of 30th ult., in trying to show that the rewards of invention cannot on any count whatever shock the community's sense of justice, says that the only people who complain about harshness of the economic laws governing invention are those who will not recognise that these laws are inevitable.

Might I crave a little space in your valuable journal to point out that the "only people" who thus complain constitute a considerable portion of the opinion of this country, both inventors and otherwise, and, moreover, that they think they see good reason to doubt that these said economic laws are unchangeable.

For instance, the economic laws governing industry in general fifty or sixty years ago under conditions, recognised by the Manchester School, of absolutely free competition are different from those existing in these times of ever-growing trusts and combines.

Similarly, since workers combined into trade unions they have considerably modified the economic laws governing their conditions of labour.

So in the same way can inventors, by combining into a society for the protection of their own interests, considerably modify the economic laws governing the reward of invention. The need for a society of this kind has apparently been recognised, as there has been one in in existence for already one year with offices in City Chambers, Broad-street, Birmingham, and during this short period it has acquired quite a considerable membership of disillusioned but still hopeful inventors.

If, as the article suggests, manufacturers have the monopoly of manufacturing knowledge and business instincts, then they must surely recognise that they should never base their calculations on what they might consider as a reasonable profit for themselves, as it is their sole business to buy their raw materials, labour and brains in the cheapest market and sell their product in the dearest. Not only this, but they do what they can, either by their individual or joint action, to control these markets.

Individual inventors at present struggle along under such handicaps as limitation of means, involving as this does lack of access to the market for ideas, and hosts of other disabilities, but if, as the article says, "nothing which outrages the sense of justice of the community can endure for very long," then it looks as if this "National Society of Inventors" might see to it that so far as inventors are concerned, injustices will not endure for very much longer.

Yours faithfully,
M. S.

11, Thornhill-terrace, Sunderland, April 3, 1923.

"THE ENGINEER AND THE CHEMIST."

To the Editor of Engineering.

SIR,—I was much interested in your editorial article entitled "The Engineer and the Chemist," in your issue of March 2, 1923. You state therein that the chemist is of little use to the engineer, and that, in the case of the collapse of Charing Cross Station, no chemist could tell the engineers why it had collapsed.

At that time I was in the employ of a very well-known firm of steel makers and engineers in England, and a section of a tie rod, the failure of which—according to the engineers—caused the entire roof to collapse, was sent to us for examination. It was a piece containing the original fracture, and was a piece of about 2-in. round material.

Microscopic examination and chemical analysis showed it to be a piece of soft wrought iron, which, of course, had a very low elastic limit and low ultimate breaking stress. Here at once was the reason why the roof collapsed. It was not a weld at all, as you state in your article. Also I venture to say that if the material of which the roof was built had been under competent chemical supervision, such unsuitable material would not have been allowed to be used.

I entirely agree with Professor Armstrong when he says that no engineer should be allowed to work without the services of the chemist. During a 25 years' experience, I have almost invariably found that the technical man, from engineer to bread baker, despises the chemist as a crank, until he finds himself in trouble. Then, and not till then, when the mischief is done, does he appeal to the chemist to extricate him from his trouble. He expects the chemist to come and put his finger right on the source of the trouble, not realising that the chemist's job is by then about ten times as difficult as if he had been utilised at the beginning.

In the case of the Charing Cross disaster, I could not, of course, certify that the fractured piece submitted to us for examination was the actual piece which caused the collapse. It was the piece which the engineers on the job claimed to be the original break which caused the whole structure to fail.

I am, yours truly,
A. FILDES,
Fellow of the Canadian Institute of Chemistry.
225, Elm-avenue, Westmount, Montreal, Canada, March 23, 1923.

[If our correspondent will refer to our issue of January 12, 1906, he will find that he is incorrect as to his opinion of the cause of the failure of the Charing Cross roof. The official inquiry showed that "the cause of the breakage was a concealed flaw, for the existence or non-discovery of which no blame could be attached to the railway company." "The end of the bar had been welded on, but the metal had been united properly over only about one-third of the section, so that the stress at that point was three times as great as it was designed to be." In view of the foregoing his suggestion that a chemist could have foretold the accident is self-refuted, and his contention that it was "a piece of soft wrought iron, which of course had a very low elastic limit and low ultimate breaking stress," is rather amusing.—ED. ENG.]

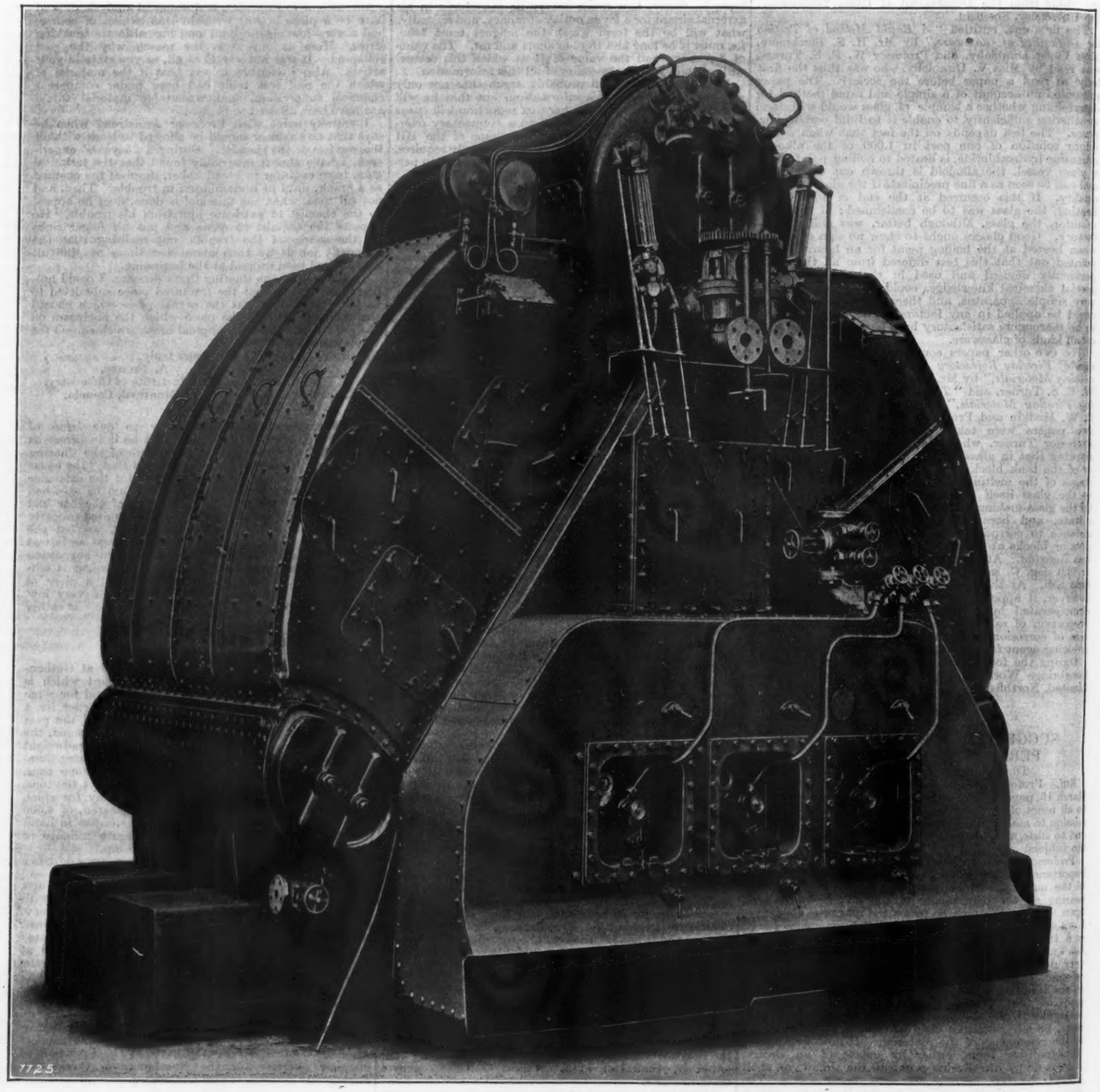
SWEDISH SHIPBUILDING.—The Göta yard at Gothenburg appears to be the only Swedish yard which is satisfactorily employed and has work on hand for some time forward. It has recently secured an order for a 5,000-ton tank motor ship. In the course of the past year the three iron ore motor vessels, the Lapponia, the Lulea and the Luossa, each of 8,200 tons deadweight capacity, have been delivered to the Grängesberg Company; the tank motor vessel Oljaren, of 7,900 tons, and the cargo motor ship, the Hjelmaren, of 4,400 tons, have been built for the Transatlantic Company, for which company another motor vessel, the Kolsnaren, of 4,500 tons, has been launched. The yard has orders in hand for 13 motor vessels having an aggregate tonnage of 70,000 tons and an aggregate of 15,000 h.p.

ENGINEER OVERSEERS FOR THE ADMIRALTY.—The new engineer overseers for the Admiralty, in connection with the construction of the battleships Nelson and Rodney, commenced their duties on Tuesday, the 3rd inst. Engineer Commander H. G. Radford has been appointed overseer at Messrs. Cammell Laird and Co.'s yard at Birkenhead, where both the hull and machinery of the Rodney will be built. In the case of the Nelson, the hull will be constructed by Messrs. Armstrong, Whitworth and Co., Limited, Walker-on-Tyne, and the machinery by the Wallsend Slipway and Engineering Company, Limited. Engineer-Commander E. W. Riley has been selected as overseer of the work on this vessel. The appointment of Engineer-Commander F. A. Chater to the President as engineer overseer for the Southampton, Cowes and Portsmouth district, is also announced.

HYDROPEAT IN FINLAND.—In the "hydropeat" process introduced at Juurikorpi, Finland, in the autumn of 1920, the peat is cut by the aid of jets of water under a pressure of 15 atmospheres or 20 atmospheres. This peculiar method was adopted among other reasons because tree trunks are very common in these peat moors, and they greatly delayed the spade work of the peat diggers. Two hydraulic jets are used, each being supplied by an electric centrifugal pump of 60 h.p.; two men work the nozzles. The jets cut into the peat and also wash the peat off the tree trunks. The thin mixture of peat and water collects at the bottom of the pit and is drawn off by a turbo-pump. The pump delivers the mixture to the drying ground, on which it is allowed to accumulate to a thickness of about 10 in.; the ground is surrounded by a 15-in. wall of peat, and outside this wall by draining ditches. The whole plant requires about 200 h.p. and 10 men. In a season of 75 days about 6,000 tons of dry peat (having 25 per cent. of water) were produced; 5 per cent. of this peat was consumed in the plant. The yield is said to represent five times the yield of the manual labour of 10 men.

YARROW WATER-TUBE BOILER WITH KERMODE SYSTEM OF OIL-FIRING.

CONSTRUCTED BY MESSRS. WILLIAM DENNY AND BROTHERS, LIMITED, ENGINEERS, DUMBARTON.



AN interesting installation of the Kermode system of oil fuel burning is illustrated in the figure above, which shows a Yarrow water-tube boiler fitted with three Kermode pressure jet burners, each of which is carried in an independent air-control casing. The boiler, which has 2,000 sq. ft. of heating surface, a working pressure of 200 lb. per square inch and an evaporative capacity of 18,000 lb. an hour, was constructed and equipped as shown in the figure, by Messrs. Wm. Denny and Brothers, Limited, of Dumbarton, and is fitted to a fire and salvage boat built by Messrs. Merryweather and Sons, Limited, of Greenwich, for the Port Authorities of Rangoon. The dimensions of the vessel are 109 ft. 6 in. overall by 20 ft. beam by 8 ft. 6 in. depth, and the draught is 6 ft. 6 in. The propelling machinery consists of two sets of triple-expansion engines with cylinders 10 in., 17 in. and 26½ in. diameter by 16 in. stroke, capable of developing 800 i.h.p., and driving twin screws. A speed of 13·18 knots was obtained on the sea trials as a mean of several runs over the measured mile, although the trials were carried out in very bad weather with a heavy gale blowing. This speed was 1·7 knots over that contracted for and was improved on by a run up and down the Long Reach measured mile, on which a speed of 13·32 knots an hour was obtained.

The Kermode burners are of the pressure atomising type and are supplied with fuel oil by direct-acting steam pumps installed in duplicate. A complete system for heating and filtering the oil is also fitted, as well as a fan driven by a high-speed steam engine for the air supply. Each burner is mounted on a front plate and discharges into an air-cone which is built up of two tubes, one of which is cylindrical and is fixed to the boiler face and the other being coned and sliding inside the first. Both tubes are furnished with air ports, and by adjusting the position of the inner coned tube the effective area of the ports may be regulated. The arrangement works with an open stokehold, and the air from the forced draught fan is led to the burners by trunk ways. As each burner is enclosed in a separate air-control casing any of them may be put out of commission without affecting the draught control of any of the others.

The burner itself consists of two concentric cylinders with an annular space between them. The oil fuel enters the burner from the side and passes along this annular space and through grooves formed in the front end of the central cylinder which abuts against a cap nut. Through these grooves the oil obtains access to the discharge opening in the cap nut. The size of this opening is controlled by a central spindle which passes through the inner cylinder and is controlled by a hand wheel at the back end of the burner. These hand wheels can be seen in the figure. In addition to this regulation of the outlet the burners may also be adjusted for different outputs by varying the pressure.

KESTNER PLUNGER PUMP FOR ACIDS.

CONSTRUCTED BY THE KESTNER EVAPORATOR AND ENGINEERING COMPANY, LIMITED, ENGINEERS, WESTMINSTER.

FIG. 1.

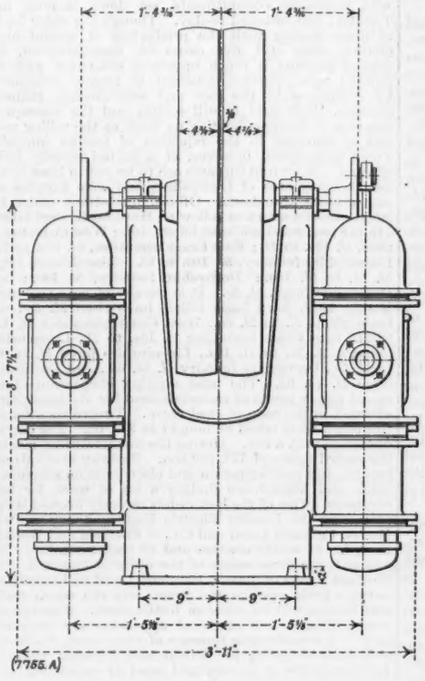


FIG. 2.

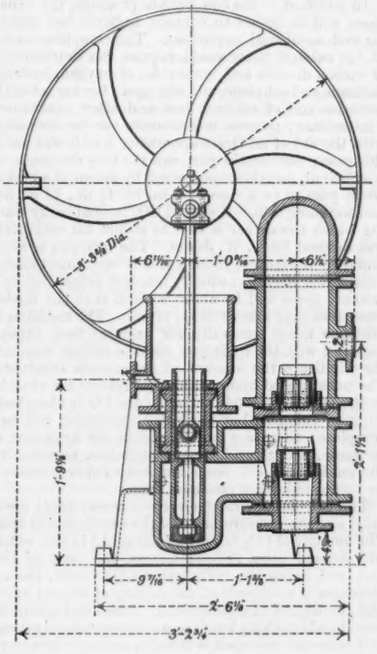


FIG. 3.

The burners do not require to be dismantled for cleaning at frequent intervals, but run for long periods without attention, so that it is only necessary to carry one spare burner for the set plus a spare set of inner tubes for each of the three working burners and the spare. Burners of this type have run for 20 hours on a naval boiler without any cleaning, but as a precautionary measure it is desirable to examine them once in each 4-hour watch. This compares very favourably with some types of burner which it has been the practice to change every 1½ hours. Detailed drawings of the Kermode pressure burner and air cone appeared in our issue of March 30, 1917.

THE KESTNER ACID PUMP.

ONE of the important items in the manufacture of sulphuric acid is the pumping of the acid to the top of the towers, in passing down which it is concentrated by contact with sulphur dioxide. Formerly, the necessary pumping was carried out exclusively by means of acid eggs, from which the acid was forced by means of compressed air. This method of pumping, which would obviously have a very low overall efficiency, has now been largely replaced by the Kestner acid elevator, in which compressed air is still employed, but in a simpler and more efficient manner. To avoid the use of compressed air many forms of pump have been tried, but in the case of diaphragm pumps difficulties have arisen from the perishing of the rubber diaphragm, while in the various types of centrifugal pumps and plunger pumps hitherto employed trouble has been experienced in most cases owing to the effect of the acid on the material used for packing the glands.

Troubles of this kind, however, appear to have been completely overcome in the pump illustrated above, since although it is of the plunger type, the usual gland or stuffing-box containing soft packing material has been eliminated. These pumps, one of which was exhibited at the London Section of the British Industries Fair by the Kestner Evaporator and Engineering Company, Limited, 5, Grosvenor Gardens, Westminster, S.W. 1, and was briefly referred to on page 232 *ante*, have been developed by the French Kestner Company, and several of them are in satisfactory use on the Continent; we believe, however, that they are quite new to this country. The general appearance of the pump is shown in the half-tone engraving, Fig. 1, on this page, and the construction and arrangement will be clear from an examination of Figs. 2 and 3, which are a front elevation and a transverse section, respectively. As will be seen, the pump illustrated is of the double-throw type, and its capacity is 1,100 gallons per hour when running at 45 r.p.m., but a single throw pump of the same design and of half the above-mentioned capacity, is also made.

The special feature of the design, which is most clearly shown in Fig. 3, is that the place of the usual stuffing-box is taken by a long sleeve in which the plunger works. Both the sleeve and the plunger are made of high-silicon iron, and the working surfaces of both are finished by grinding so as to leave just sufficient clearance between them to permit a very small quantity of the acid being pumped to leak through. This leakage acid, which acts as a lubricant for the working surfaces, amounts to only a few drops per hour, but it is collected in a cup-shaped vessel bolted on to the upper end of the pump body and returned to the pump suction, through the connection shown on the left of Fig. 3. The leakage, it should be mentioned, does not continue when the pump is at rest, since the pressure due to the head of acid in the delivery pipe is then sustained by the delivery valve.

The remaining details of the pump call for no particular comment, but we may add that the plungers are 100 mm. (3·94 in.) in diameter and have a stroke of 160 mm. (6·3 in.). The valves are of high silicon iron and the other parts coming into contact with the acid are of cast-iron, high-silicon iron or regulus metal according to the degree of concentration of the acid to be pumped.

In general it may be remarked that the construction is particularly substantial throughout, and the pump can run continuously for long periods without any attention other than the lubrication of the bearings. The essential features of the design are, of course, protected by patents.

AUTOMOBILE EXHAUST GASES.

A PAPER on the "Sampling and Analysis of Automobile Exhaust Gases," recently contributed to the journal of the Franklin Institute by Messrs. A. C. Fieldner and G. W. Jones, of the United States Bureau of Mines, is of considerable practical interest. It does not deal with the poisonous character of these gases and the danger which these gases and the fuel vapours may cause. Those problems had already been discussed in reports published by the New York Tunnel Commission* and in other papers. Nor is the main interest of this recent contribution chemical; but the chemical methods described enable the engineer to control the efficient working of his engine in the garage as well as when running on a level road or up hill. Such a control is already exercised to a certain extent, of course. But analyses of samples of exhaust gases, taken by the Bureau during road tests of 101 automobiles and trucks under normal conditions, indicated an astonishingly large loss of motor spirit due to incomplete combustion, and, further, that half of this loss could be prevented by proper adjustment of the carburettor. The tests should therefore be adopted as routine practice.

The sampling tube used in these experiments is a copper tube, ¼ in. to ⅜ in. diameter, so fixed in the exhaust manifold between engine and silencer that the opening of the bent tube end faces the flow of gases. The clamp holding the tube consists of two halves which are bolted to the exhaust pipe. Over the outer end of the copper tube is slipped a stout rubber tube leading to a glass T of the apparatus. Through the horizontal branch of the T and a tube carried further to a water seal the exhaust gas can escape into the atmosphere, the seal preventing air from being sucked back into the sample.

The vertical stem of the T is joined by rubber tubing to a glass bulb, 250 cub. cm. in capacity, the sample container, which is filled with salt water (5 per cent. solution) and closed by stopcocks at the upper and lower extremities. When a test is taken, the experimenter opens the stopcocks so that the water of the container flows out into a jar underneath, being replaced by the exhaust gas; when all the water has been discharged, the stopcocks are closed again; the excess exhaust meanwhile bubbles through the seal mentioned. The water collected in the jar is re-used.

The grab or intermittent sampling method is simpler than the method just described. The container is in this case a bulb of glass or metal, fitted with stopcocks and directly inserted into the exhaust pipe between the engine and silencer. The cocks of this container are kept open for a sufficiently long time to replace the air in it by the exhaust gas. Several containers should be charged during a test so as to obtain a fair average; but this remark does not apply to the grab method only. In either method a stock of sample containers has to be carried, and a continuous method of sampling would be preferable. There is also an objection to the water charge of the container, since this water will absorb some of the carbon dioxide in the gas; but when the water is re-used, as we mentioned, the absorptive power of the more or less saturated water for CO_2 diminishes with repeated usage. Comparative experiments made with water and with mercury as container liquids, and with

* See ENGINEERING, vol. cxiii, page 79.

charging periods ranging from 5 minutes up to 20 minutes, showed a maximum error in the final CO_2 percentage deduced of only 1 per cent., however, and in most cases the error was very small. The particular position of the sampling tube in the exhaust pipe was also found to make very little difference.

In addition to the combustion products, the exhaust gases will be found to contain unburnt-fuel vapours, air and accidental impurities. The complete analysis of the exhaust gases would require the determination of carbon dioxide and monoxide, of oxygen, hydrogen, methane and ethylene, and nitrogen; further, of carbon particles and of mineral dust and other constituents. The ordinary gaseous constituents can be determined with the aid of an Orsat apparatus, which was used in this case; for certain purposes the CO_2 determination is sufficient, and this was effected by means of a portable Orsat packed in a case of 7 in. by 4½ in., 14 in. high, and weighing 5 lb. A special CO_2 indicator, by watching which the driver is able to adjust his carburettor, was devised by G. W. Jones. The nitrogen is always found by difference, though this is very unsatisfactory considering that the ordinary nitrogen percentage in the exhaust gases will be about 80, and that the mode of procedure may mask serious errors. The methane and ethylene stand generally for unburnt fuel vapours; together with the hydrogen and the carbon monoxide, they indicate the amount of incomplete combustion. The unsaturated hydrocarbons (ethylene) are absorbed, in the Orsat, by sulphuric acid; the CO is absorbed by cuprous chloride, but the latter absorption will be incomplete; there are no absorbents for hydrogen and methane, and these latter constituents, together with the unabsorbed CO, are submitted to slow combustion by means of heated platinum wire.

The calculations of the various constituents are not easy, and the interpretation of the results is still less so. The amount of CO_2 (about 12 per cent.) in the exhaust will depend upon various factors, the ratio of air to fuel, and hence the carburettor adjustment, the completeness of evaporation, the mixing of air and vapour, and the degree of compression. The ideal combustion would yield nothing but CO_2, water vapour and nitrogen. But some air will always leak in, and any free oxygen found in the gases may be due to an excess of air (lean mixture) as well as to a large excess of vapour (rich mixture); a mist of vapour might not be ignited by a spark, especially when the cylinder is still cold, and in a very rich mixture the flame would not travel, so that oxygen remains present in spite of incomplete combustion. In such cases we would also find CO, methane and hydrogen in the gases. The relative proportions of the hydrogen—from decomposed fuel and also from water vapour reactions,—and methane, are difficult to estimate. The CO percentage amounted in the 101 trial runs mentioned to about 6·5. This means that nearly a third of the available heat energy was wasted; in one case the CO percentage rose to 13·2, and there is little doubt that there is a good deal of fuel wasted in actual motor driving.

CONTRACTS.—The Power-Gas Corporation, Limited, have completed the construction and erection of a water-gas plant for Synthetic Ammonia and Nitrates, Limited, of Billingham. The plant comprises three mechanical generators and auxiliaries with a rated capacity of 6,000,000 cub. ft. of gas per day, and will represent the most modern practice in water gas production on a large scale.

PAST AND PRESENT CREWE PUPILS AND PREMIUMS DINNER.—We understand that the 34th annual dinner of the past and present Crewe pupils and premiums will be held this year on Friday, May 11, at the Grand Hotel, Trafalgar-square, London, at 7.30 p.m. Mr. H. P. M. Beames is presiding, and we have been asked by the hon. secretary, Captain R. Terrell, of 39, Sloane Gardens, S.W. 1, to request past Crewe men who wish to attend this function to communicate with him.

THE LATE MR. JOHN R. R. WILSON.—Many friends will hear with great regret the news of the death of Mr. John Robert Robinson Wilson, His Majesty's Inspector of Mines and Quarries for the Newcastle district, which occurred in a nursing home on Tuesday, April 3. Mr. Wilson was born in 1862 and received his scientific training at the Yorkshire College, Leeds. He acquired an extensive experience in mining work as assistant to the late Mr. Benjamin Wilson, general manager of the Swaithe Main Collieries, Barnsley, and had charge of the Edmunds Main Colliery, Barnsley. In 1888, Mr. Wilson was appointed assistant to Mr. Alexander Macnab, the engineer to Mr. T. A. Walker, the contractor for the construction of the Manchester Ship Canal. On the completion of the canal contract in 1891, Mr. Wilson joined the staff of Mr. C. E. Bartholomew and was engaged on prospecting for minerals in the Midland Counties during the next two years. Afterwards he was appointed an Inspector of Mines in the Yorkshire and Lincolnshire districts, and later in the Newcastle district. He was a member of the Institution of Civil Engineers, a member of council of the Institution of Mining Engineers, a vice-president of the Midland Institution of Mining, Civil and Mechanical Engineers, and a Fellow of the Geological Society.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The majority of the steel engineering works in the South Yorkshire area continued operations over Good Friday and Saturday in order to keep pace with increasing commitments, set down Monday and Tuesday, and resumed to-day. Though the order books of firms dealing with the production of special high-quality steels still give cause for dissatisfaction, the general position is much improved compared with six months ago. Current business is largely dominated by conditions in the raw and semi-finished material sections. Soft steel is still scarce, and the consequent shortage of billets is holding up work at the rolling mills and is resulting in the rejection of foreign inquiries. There is prospect, however, of a partial remedy being effected. More iron furnaces are to be put in blast in the neighbouring area of Derbyshire, and coke supplies are rather more abundant. Official quotations under the latest revision stand as follow:—Hard basic steel billets, 11*l.* per ton; soft basic steel billets, 10*l.*; West Coast hematites, 6*l.* 15*s.* to 7*l.*; East Coast hematites, 6*l.* 15*s.* to 7*l.*; Lincolnshire foundry, 5*l.* 10*s.* to 6*l.*; Lincolnshire forge, 5*l.* 5*s.* to 5*l.* 10*s.*; Derbyshire foundry, 5*l.* 10*s.*; and Derbyshire forge, 5*l.* 5*s.* It is worthy of note that since March, 1922, hard basic billets have risen 2*l.* 5*s.*, soft basic billets 2*l.* to 2*l.* 5*s.*, West Coast hematites 1*l.* 15*s.* to 2*l.*, East Coast hematites 1*l.* 15*s.* to 2*l.*, Lincolnshire foundry 1*l.* 5*s.* to 1*l.* 10*s.*, Lincolnshire forge 1*l.* 2*s.* 6*d.* to 1*l.* 5*s.*, Derbyshire foundry 1*l.* 7*s.* 6*d.*, and Derbyshire forge 1*l.* 7*s.* 6*d.* The most striking illustration of the recent rise in prices of materials used for steel-making is afforded in the case of steel scrap. Twelve months ago this commodity could be bought at 37*s.* 6*d.* The current quotation is 5*l.* a ton. During the war steel scrap reached the record figure of 12*l.* per ton. Railway renewals and repairs, and reconstruction and electrification schemes at home and abroad, are finding a lot of work for local engineers. One of the best orders recently booked is that placed by the London Electric Railway Company with Messrs. Cammell Laird and Co., of Sheffield and Nottingham, for 41 motor coaches and 40 trailer coaches. The approximate gross value of the order is 300,000*l.* The Sheffield works of Messrs. Cammell Laird will supply the axles, wheels, springs and tyres, and the coach bodies and fittings will be made in Nottingham. Carriage and wagon fittings and electrical apparatus are improving lines. A considerable tonnage of wire ropes, machinery and tools is going to British and Colonial collieries. Russian trade in agricultural steel is expanding on a cautious basis. The cash-against-document arrangement has not worked too satisfactorily, but under the latest scheme of cash against orders, the former difficulty of cancellation after the manufacture of the goods required, is removed.

South Yorkshire Coal Trade.—The market re-opens with sellers generally in a fairly strong position The only exception is house coal, where for months the local and metropolitan demand has been well below the seasonal level. Now that collieries have tided themselves over the holiday set-down, more slack is available for industrial consumption. Coking qualities are particularly in demand. Collieries are well booked forward in best steams, cobbles and nuts. Gas coke is an improving market. Quotations:—Best handpicked branch, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 17*s.* to 19*s.*; Yorkshire hards, 22*s.* to 24*s.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 11*s.* to 12*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 6*s.* to 8*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is next to nothing doing in Cleveland pig-iron. Occasional small parcels come unexpectedly on the market and they are promptly snapped up at high figures, but generally makers and merchants alike have no iron to offer for April-May, and both buyers and sellers show disinclination to commit themselves beyond that period. Quotations are thus nominal. No. 1 is 132*s.* 6*d.*, No. 3 has realised 130*s.*, though 127*s.* 6*d.* is given as the recognised market figure. No. 4 foundry is 125*s.* and No. 4 forge 120*s.*

Hematite.—East Coast hematite is extremely scarce. Most makers have withdrawn from the market after having disposed of their output to June, but merchants have still a little iron available for disposal. Nos. 1, 2 and 3 are in the neighbourhood of 127*s.* 6*d.* for May-June delivery, but contracts further forward might be arranged at 125*s.*

Manufactured Iron and Steel.—Firmness of the various descriptions of finished iron and steel is undisturbed. Manufacturers are busy, and quite good inquiries are circulating, but there is a growing feeling that customers will not follow further upward movement in prices. Common iron bars are 12*l.*; iron rivets, 14*l.*; black sheets, 15*l.*; hard steel billets, 10*l.* 15*s.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel boiler plates, 14*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.* 5*s.*; heavy sections of steel rails, 10*l.* 10*s.*; fish plates, 14*l.* 10*s.*; and galvanised corrugated sheets (No. 24 gauge, in bundles), 19*l.* 10*s.*

Shipments of Iron and Steel.—Shipments of iron and steel from the Tees—including 11,024 tons of pig-iron cleared at Skinningrove—for the month of March are returned at 124,390 tons, comprising 67,618 tons of pig-iron, 4,163 tons of manufactured iron, and 52,609 tons of steel. Of the 56,414 tons of pig-iron despatched from Middlesbrough, 50,197 tons went overseas and 6,217 tons went coastwise; of the manufactured iron cleared, 2,604 tons went overseas, and 1,559 tons went coastwise; and of the steel shipped, 43,412 tons went overseas and 9,197 tons went coastwise. Germany was the largest customer of pig-iron, taking 19,957 tons; whilst the United States came second with 11,205 tons; Italy imported 7,510 tons; Belgium, 4,488 tons; Scotland, 3,077 tons; France, 3,030 tons; Wales, 2,980 tons; Denmark, 2,192 tons; and Canada, 1,000 tons. India was again the largest customer for manufactured iron and steel, taking 1,934 tons of the former and 14,705 tons of the latter. Other principal importers of steel were:—Natal, 3,902 tons; Victoria, 3,785 tons; Burmah, 3,073 tons; South Australia, 3,072 tons; Japan, 2,183 tons; New South Wales, 1,859 tons; and Cuba, Nigeria, Cape of Good Hope, and the Straits Settlements, each over 1,000 tons.

Ironstone Miners Revert to Eight-Hours' Day.—Cleveland ironstone miners have reversed their decision, decided by a small majority, rejecting the employers' request to return to the 8-hours' working day. Whilst now agreeing to the longer day, however, they claim the right to raise the question again at the expiration of six months. The change involves an addition to the actual working day of about half an hour, as the 7-hours' day recently worked excluded time employed by the miners in travelling from bank to face, whereas the 8-hours' working day is from bank to bank. The satisfactory amicable agreement promises to be speedily followed by the opening out of idle mines.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—A good healthy tone continues to prevail in the Scottish steel trade, and order books are well filled up for some time ahead. Makers are certainly in a much better position than they were a month or two ago, and as the general demand is good and looks like lasting there is a feeling that the industry is on the eve of better times. The shipbuilding trade is still extremely quiet, and as a result there is little business passing for ship plates, and that is perhaps the slowest side of the steel trade. Black sheet makers are actively employed and most of the mills are running at full speed. Home consumers are taking up large quantities of sheets and there is also a heavy tonnage going abroad. The general inquiry for steel material is increasing, and much of it means business provided buyers can wait for delivery until the most pressing orders on hand are fulfilled. Prices are very firm, but show practically no change from last week and are as follow:—Boiler plates, 13*l.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, 12*l.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The state of the malleable iron trade in the West of Scotland shows little change over the week. Home buyers are not taking up quite so much material, but the export side shows little in the way of a falling-off meantime. For re-rolled steel bars, &c., there is quite a brisk demand, and plant is fully employed. Prices are very firm, and the rising tendency of the market has brought out a fairly heavy inquiry, but producers are holding out for higher quotations, which buyers do not seem inclined to give. "Crown" bars are called 12*l.* 10*s.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—The Scottish pig-iron makers are experiencing very satisfactory conditions at the present time, and all the furnaces now in blast are working at full pressure. With the steel trade much brisker there is quite a steady demand for hematite, production of which was recently increased, while the output of foundry grades is exceptionally good and there is no dearth of buyers even at to-day's level of prices. The latter are firm and the following may be taken as the current quotations:—Hematite, 6*l.* 7*s.* 6*d.* per ton, delivered at the steelworks; foundry iron, No. 1, 6*l.* 5*s.* per ton, and No. 3, 6*l.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, March 31, were approaching ten times the tonnage shipped during the corresponding week of last year. The total was 6,319 tons, of which 6,115 tons went foreign and 204 tons coastwise. The corresponding figures a year ago were 515 tons foreign and 149 tons—a total of 664 tons.

Shipbuilding.—The shipbuilding returns for the past month, while better to a considerable extent than for either of the two previous months, were not up to the average monthly output. It is unfortunate that as many of the building berths are cleared there are few orders on hand to be laid down and thus keep up the rotation, but as the present cost of construction is so high shipowners are not meantime giving out fresh contracts. The returns for the different Scottish districts for the past month and also for the three months are as follow:

	March, 1923.		Three Months 1923.	
	Vessels.	Tons.	Vessels.	Tons.
The Clyde	11	33,663	20	68,204
The Forth	2	2,842	6	4,992
The Tay	—	—	1	8,000
The Dee and Moray Firth	1	1,500	3	2,190
Total output ...	14	38,005	30	83,386

With reference to the Clyde output for the month, while it is better than for the same month of last year by

6,800 tons, it only brings the total tonnage for the first quarter of the year up to 68,204 tons, which is the lowest total for many years. The same three months last year gave us a total output of 106,062 tons, and the previous year the figure was 149,841 tons, so that 1923 is a good long way behind. Few new contracts have been reported during the past month, and few can be expected so long as costs remain at such a high level as at present prevail.

Portuguese Contract for Glasgow.—An important contract of considerable dimensions has just been secured by Messrs. William Beardmore and Co., Limited, Glasgow. It is for the supply, construction and equipment of the general workshops for the Portuguese South and South-Western Railway at Barreiro. The workshops are for the construction, maintenance and repair of locomotives, carriages, wagons and rolling-stock generally, required in connection with the railway system, and when completed will be an example of the most modern railway workshop lay-out and organisation. The contract was secured in open competition with other British and Continental firms, Germany included, and each firm had to send in their own design of buildings and general lay-out.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Conditions in the South Wales coal trade are more difficult than was the case before the holidays. Then the scarcity of free supplies was pronounced and shippers experienced difficulty in securing even small parcels. Now as a result of stoppages in the coalfield over the non-unionist question, outputs are bound to be diminished with the natural result that the quantity available for disposal on the market will be lessened. The detention to shipping is also aggravated, for boats requiring cargoes or bunkers from the collieries rendered idle will be further delayed. Already the docks are congested with shipping, and in addition to more than 320 vessels actually in the dock, there were also 45 in the roadsteads waiting to come into dock. Of those in dock 97 were under the tips and yet there were 44 waiting for loading berths. In the circumstances operators are not keen to transact business. Colliery salesmen in particular are reluctant to sell, and prefer to await developments in connection with the non-unionist stoppages. To-day some 40,000 colliery workers were on strike in the Rhondda district though in other parts of the coalfield the instruction of the Miners' Federation to come out was ignored. Exports of coal as cargo last week amounted to 636,800 tons, or 9,000 tons more than in the previous week, but 23,000 tons less than in the week ended March 16. France as usual took the bulk of the Welsh shipments, for 249,400 tons went to that country of which 58,500 tons went to Rouen, 40,500 tons to Marseilles, 24,000 tons to Bordeaux, and 16,000 tons to Dunkirk. Exports to Italy totalled 116,500 tons, and included 12,000 tons to Venice. Shipments to South America amounted to 57,200 tons, of which 46,400 tons were despatched to Buenos Aires. Exports to Spain amounted to 25,200 tons, to Portugal, 12,900 tons, to Greece 1,500 tons, to the United States 10,700 tons, to British coaling depots to 41,100 tons, and to unclassified destinations to 122,200 tons, including 45,500 tons to Germany, 23,700 tons to Holland, and 10,000 tons to Scandinavia. Shipments from the port of Cardiff at 418,200 tons, reached the highest total for any week of this year. Those from Newport amounted to 116,580 tons, Swansea 57,600 tons, Port Talbot 36,800 tons and Llanelly to 7,500 tons. Exports of patent fuel totalled 4,890 tons, compared with 4,400 tons in the previous week, and of coke to 7,600 tons, compared with 8,700 tons. Shipments of oil from Cardiff included 1,676,745 gallons to Rotterdam, and an interesting feature of this shipment is the fact the cargo was transhipped in the Cardiff Roads from a vessel which had lost her rudder and was towed to the Roads from the Lizard.

BRITISH CORPORATION FOR THE SURVEY AND REGISTRATION OF SHIPPING.—This corporation has now issued the third supplement, of additions and corrections, to its current register.

NEW DIRECTOR OF DOCKYARDS.—The post of Director of Dockyards relinquished by Vice-Admiral Sir Laurence E. Power, K.C.B., C.V.O., at the end of the last financial year, on the 31st ultimo, has been filled by the appointment of Rear-Admiral Brian H. F. Barttelot, C.B., M.V.O. Rear-Admiral Barttelot was formerly Rear-Admiral-in-Charge at Malta and Admiral-Superintendent of the dockyard there, and before his appointment to Malta acted for some years as Captain-Superintendent of contract-built ships in the Clyde district.

THE LATE MR. SIDNEY HERBERT WELLS.—The founder of the Junior Institution of Engineers, Mr. Sidney Herbert Wells died at St. Leonards, on March 28. He was born in 1865, and received his engineering education at Birkbeck and King's Colleges, London, winning a Whitworth Scholarship in 1885. After two years as a master at Dulwich College, he went to Leeds University, in 1891, as senior assistant to the professor of engineering. He was later appointed principal of the Battersea Polytechnic. After visiting Egypt in 1906, to report on technical education, he was appointed Director-General of the Egyptian Department of Technical, Industrial and Commercial Education. For his work as Director of Civilian Employment for the Egyptian Expeditionary Force he received the C.B.E., and also held the orders of the Medjidieh and the Nile. He was an associate member of the Institution of Civil Engineers, and an original member of the Faculty of Engineering of London University.

NOTICES OF MEETINGS.

THE INSTITUTE OF TRANSPORT.—Friday, April 6, at 5.30 p.m., in the Lecture Theatre of the Institution of Electrical Engineers, Victoria Embankment, when a paper will be read on "The Influence of Transhipment on Railborne and Road Traffic, with Special Reference to the Most Economical Methods of Labour-Saving Appliances." Mr. J. Rostern, C.B.E. (Member of Council) will deal with that portion of the paper relating to "Operating" and Mr. C. Bentham (Member), with "Labour-Saving Appliances." Tuesday, April 10, at 6 p.m., a Meeting of the Metropolitan Graduates and Students' Society will be held in the building of the Institution of Electrical Engineers, at which Mr. E. W. Bayliss (Graduate) will read a paper entitled "Tramways—Their Scope, Object and place in a Comprehensive Scheme of Transport and in Municipal Enterprise."

THE INSTITUTE OF MARINE ENGINEERS.—Friday, April 6, at 6 p.m., at 85-88, The Minories, Tower Hill, E. 1. Annual Meeting. Tuesday, April 17, at 6.30 p.m. "The Operation of Water-tube Boilers for Cargo and Passenger Service," by Mr. R. Clark.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, April 7, at 2 p.m., in the Lecture Theatre of the Institute, Newcastle-upon-Tyne. The following paper will be read: "Demonstrations of Coal-dust Explosions at Eskmeals, 1922, Cinematograph Film," by Professor R. V. Wheeler, D.Sc. The following paper will be open for further discussion: "Abstract of Recent American Coal-dust Experiments," by Professor Henry Louis, M.A., D.Sc., A.R.S.M.

THE CLEVELAND INSTITUTION OF ENGINEERS.—Monday, April 9, at 7.15 p.m., in the Hall of the Cleveland Technical Institute, Corporation-road, Middlesbrough, when a paper will be read on "The Physical Properties of a New Alloy Allied to Bronzes," by Mr. E. Hall Craggs, M.Inst.C.E.

THE SOCIETY OF ENGINEERS.—Monday, April 9, at 5.30 p.m., at the Geological Society, Burlington House, Piccadilly, W. Paper on "The Work of the Labour Corps in France during the War, with particular reference to the 178th Labour Company," by Mr. T. Exley-Fisher.

THE INSTITUTION OF CIVIL ENGINEERS; NEWCASTLE-UPON-TYNE ASSOCIATION.—Monday and Tuesday, April 9 and 10, at 7.30 p.m., in the Lecture Theatre, Neville Hall, Newcastle-upon-Tyne. Vernon Harcourt Lectures, by Mr. T. R. Wilton, M.A., on "Foundation in Dock and Harbour Works."

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Tuesday, April 10, at 7.30 p.m., at 207, Bath-street, Glasgow. Paper by the late Dr. Gisbert Kapp, on "The Improvement of Power Factor," will be read by Mr. R. B. Mitchell.

THE INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Tuesday, April 10, at 7 p.m., in the Chamber of Commerce, New-street. Annual General Meeting.

THE INSTITUTE OF METALS: NORTH-EAST COAST LOCAL SECTION.—Tuesday, April 10, at 7.30 p.m., in the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne. Annual General Meeting.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 10, at 6 p.m. Paper to be submitted for discussion: "The King George V. Dock, London," by Asa Binns, M.Inst.C.E.; and ballot for new members. Wednesday (afternoon), April 11, Students' visit to the Golder's Green—Edgware Extension of the London Electric Railways.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, April 10, at 7.30 p.m., in the Rankine Hall, 39, Elmbank-crescent, Glasgow. Annual General Meeting. Papers to be read and discussed: "The Beardmore-Tosi Diesel Engine: Results of Test Bed and Sea Trials," by Mr. Robert Love; "Some Oil Engine Experiments," by Mr. A. I. Nicholson, B.Sc.; "Electric Transmission of Power for Propelling Machinery," by Mr. W. J. Belsey; "The Arch Principle of Ship Construction," by Mr. Maxwell Ballard.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, April 10, at the Royal Society of Arts, John-street, Adelphi, the following paper will be read: "Potrero No. 4. A History of One of Mexico's Earliest and Largest Wells," by Mr. A. E. Chambers, M.Inst.P.T.

THE INSTITUTION OF ELECTRICAL ENGINEERS: WIRELESS SECTION MEETING.—Wednesday, April 11, at 6 p.m. "The Application of a Revolving Magnetic Drum to Electric Relays, Siphon Recorders and Radio Transmitting Keys" (experimental demonstration), by Mr. N. W. McLachlan, D.Sc.(Eng.), Member.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS (INCORPORATED).—Wednesday, April 11, at 6.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment. "Some Notes on Railway Accidents," by Mr. G. Holt (Member).

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, April 11, at 8 p.m., at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, when the following papers will be read: "The Steam Wagon from the Designers' Point of View," by Mr. F. J. Bretherton, and "The Use and Limitations of the Steam Wagon," by Mr. C. le M. Gosselin.

THE MANCHESTER METALLURGICAL SOCIETY.—Wednesday, April 11, at 7 p.m., in the College of Technology, Whitworth-street, Manchester. Lecture by Dr. W. H. Hatfield, A.M.I.Mech.E., on "Corrosion in Relation to Metals Used in the Mechanical Arts."

THE INSTITUTE OF METALS: LONDON LOCAL SECTION.—Thursday, April 12, at 8 p.m., at the Institute of Marine Engineers, 85-88, The Minories, Tower Hill, E. 1. Annual General Meeting. Paper on "The Surface Tension of Metals," by Mr. S. W. Smith, D.Sc.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, April 13, at 9 p.m. The evening discourse will be delivered by Mr. W. H. Eccles, D.Sc., F.R.S., on "Studies from a Wireless Laboratory." Afternoon Lecture at 3 p.m.: Thursday, April 12, Professor A. O. Rankine, O.B.E., D.Sc., on "Transmission of Speech by Light" (Lecture I).

THE INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Friday, April 13, at 7.15 p.m., at the University College, Singleton-park, Swansea. Paper on "Casting and Castings," by Professor C. A. Edwards, D.Sc.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, April 13, at 3 p.m., in the Mappin Hall of the University, St. George's-square, Sheffield. Joint Meeting with the Faraday Society and the Manchester Metallurgical Society.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 13, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Ordinary Meeting. Paper on "The Instrument Equipment of Aeroplanes," by Mr. C. B. Clapham, B.Sc.

THE DIESEL ENGINE USERS' ASSOCIATION.—Friday, April 13, at the Institution of Electrical Engineers, Victoria Embankment, W.C. 2. Notes on "The Use of Cooling Water for Diesel Engines," by Mr. J. G. Griffin, M.I.E.E.

THE ROYAL INSTITUTE OF BRITISH ARCHITECTS' PRIZES.—The Royal Institute of British Architects has just published its annual announcement of prizes. These include a travelling studentship of a total value of 500*l.* and others of 150*l.*, 100*l.*, 75*l.*, and lesser amounts. The total value of the prizes and studentships offered this year by the Royal Institute of British Architects for the encouragement of architectural students is nearly 2,000*l.* Full particulars of these prizes can be obtained on application to the secretary of the Royal Institute of British Architects.

TRANSATLANTIC RADIOTELEPHONY.—It will be remembered that in January last the Western Electric Company, acting in conjunction with the American Telephone and Telegraph Company and the Radio Corporation of New York, gave a very successful demonstration of radiotelephony across the Atlantic, which was duly recorded in our issue of January 19, on page 80. The system employed was more fully explained by Dr. H. W. Nichols in a lecture delivered before the Institution of Electrical Engineers on February 22, and an article based on this lecture will be found in our issue of March 2, on page 272. Although the demonstration above referred to was completely successful, it by no means follows that a satisfactory commercial service could at once be instituted on similar lines. We learn, however, that the Postmaster-General has recently appointed a committee to consider from a technical standpoint the possibility of transatlantic radiotelephony for commercial use and to advise what practical steps can be taken to develop this means of communication. The committee will meet under the chairmanship of Admiral Sir Henry Jackson, and will include Major-General Sir F. H. Sykes, Mr. R. A. Dalzell, Professor W. H. Eccles, Mr. F. Gill and Mr. E. H. Shaughnessy, while Major A. G. Lee will act as secretary. It is understood that the American telephone authorities are anxious to co-operate in any efforts to make telephonic communication across the Atlantic a practical means of commercial intercourse.

GOTHENBURG EXHIBITIONS.—The City of Gothenburg, the principal centre of seaborne trade in Sweden, will hold an exhibition from May 8 to September 30, to commemorate the tercentenary of its foundation. A number of other shows and fairs will be arranged contemporaneously by different organisations, including an International Automobile Exhibition and an International Aero Exhibition. In accordance with the rules laid down at the meeting of the Bureau Permanent International des Constructeurs d'Automobiles in November last, the Automobile Exhibition will be open for a period of five weeks commencing on May 9 and closing on June 12. The motor vehicles (including motor cars, trucks and lorries) imported into Sweden at different periods, are as follow:—

	1913.	1919.	1920.	1921.	First Six Months, 1922.
Great Britain ..	63	74	166	39	176
U.S.A.	285	1,641	5,373	1,604	1,653
France	46	6	209	163	34
Germany ..	262	1,581	3,241	900	482
Other countries ..	21	358	2,427	2,575	1,745

As will be seen the demand for British cars showed a marked increase during the first six months of last year. In Sweden, as in other countries, the small car is at present very popular, and the Swedish Consul-General in London thinks there can be no doubt that British manufacturers of such cars could secure an increased demand if they would care to make more determined efforts to render the Swedish public familiar with the high standard of the British product. Further particulars may be obtained from the offices of the Swedish Consulate General, Bank Chambers, 329, High Holborn, W.C. 1.

IRONCLAD SWITCHGEAR FOR EXTRA HIGH TENSION CIRCUITS.

CONSTRUCTED BY MESSRS. A. REYROLLE AND CO., LIMITED, ENGINEERS, HEBBURN-ON-TYNE.

(*For Description, see Page* 438.)

FIG. 1. 11,000-VOLT THREE-PHASE SWITCHBOARD; FRONT VIEW, SHOWING ONE SWITCH REMOVED.

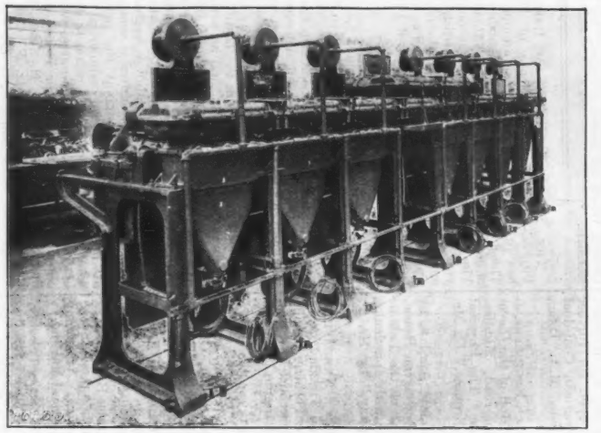


FIG. 2. 11,000-VOLT THREE-PHASE SWITCHBOARD; BACK VIEW.

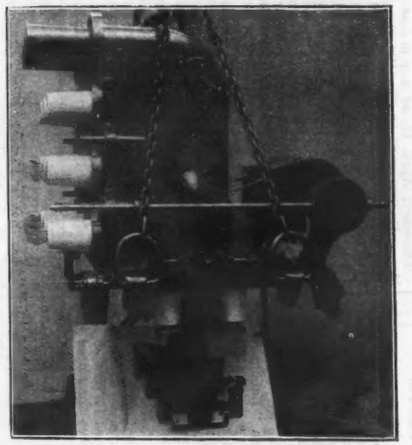


FIG. 5. 20,000-VOLT DUPLICATE BUS-BAR HAND OPERATED SWITCH, SHOWING SUSPENSION OF THE BRUSH CONTACTS.

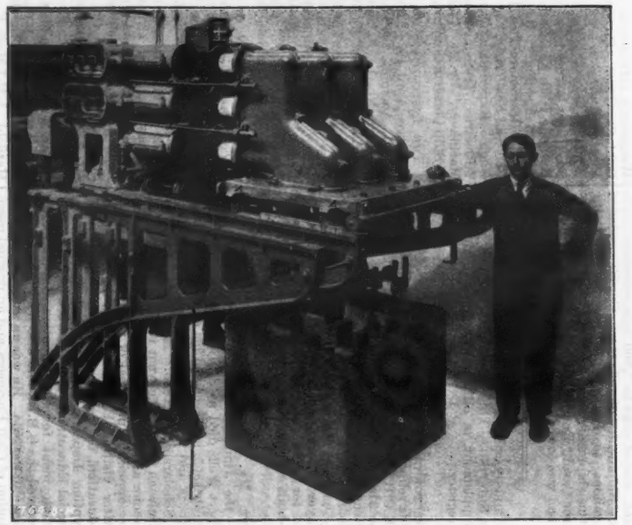


FIG. 3. 20,000-VOLT SWITCH, WITHDRAWN FOR INSPECTION.

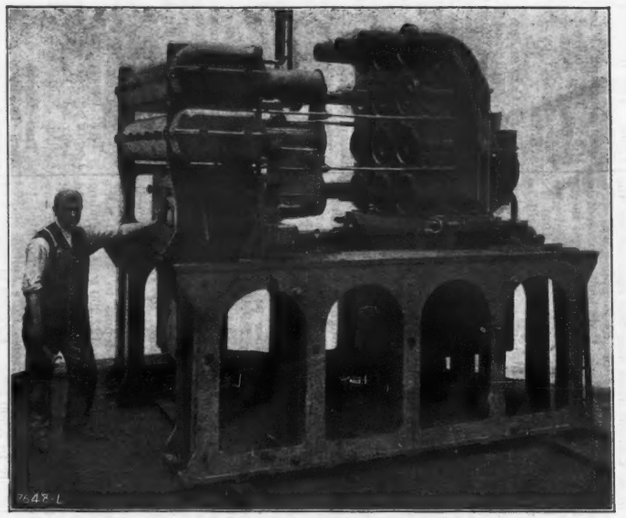


FIG. 4. 33,000-VOLT SOLENOID OPERATED SWITCH, WITHDRAWN FOR INSPECTION.

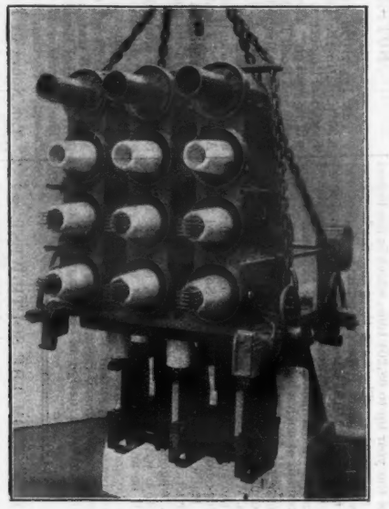


FIG. 6. FRONT VIEW OF 20,000-VOLT DUPLICATE HAND OPERATED BUS-BAR SWITCH.

IRONCLAD SWITCH-GEAR FOR EXT

CONSTRUCTED BY MESSRS. A. REYROLLE AND CO.,

(For Description, see

Fig. 7.

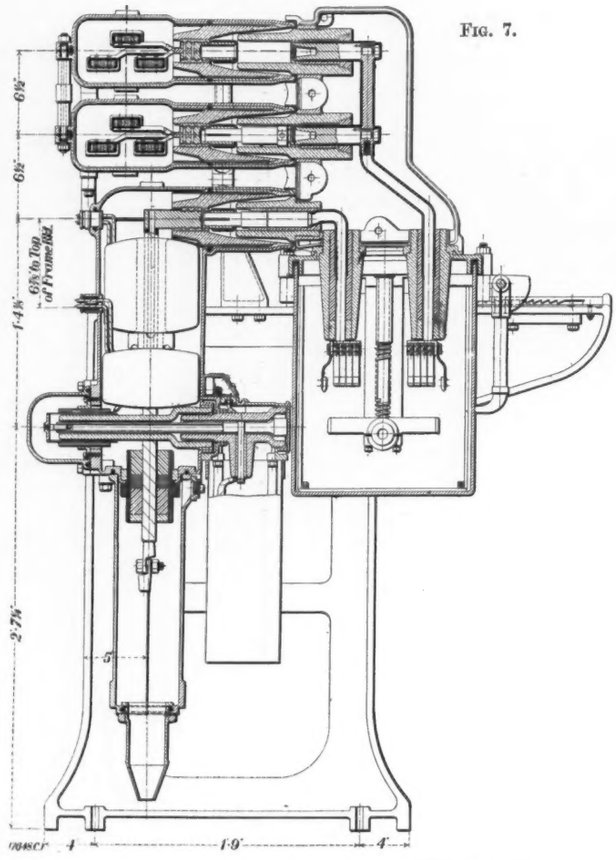


Fig. 8.

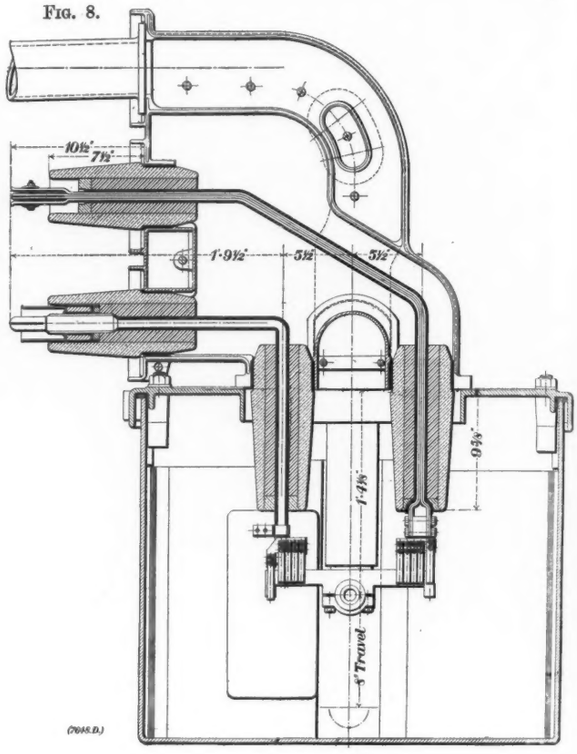


Fig. 9

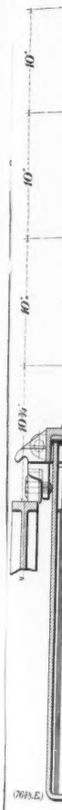


Fig. 10.

FRONT ELEVATION
with Cover Shown in Section.

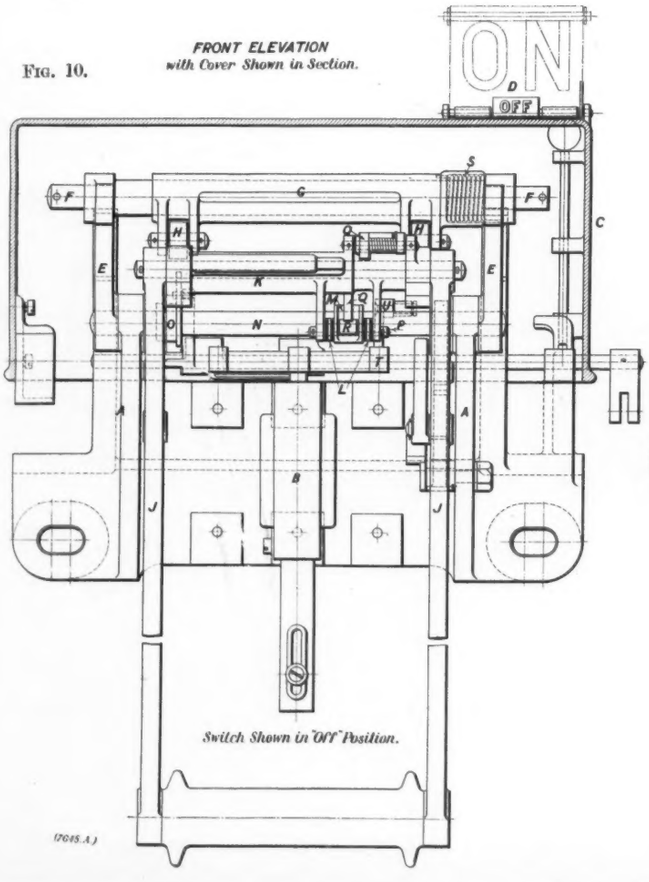


Fig. 11.

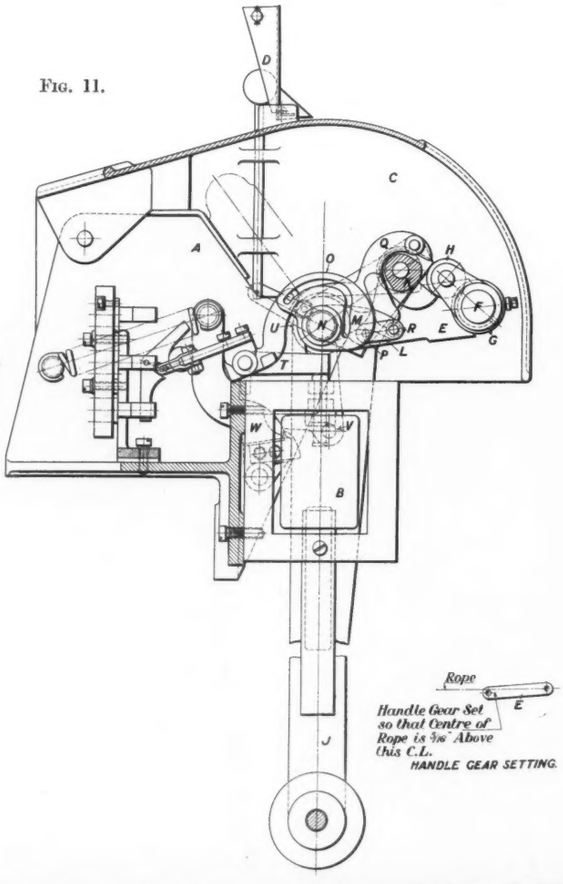
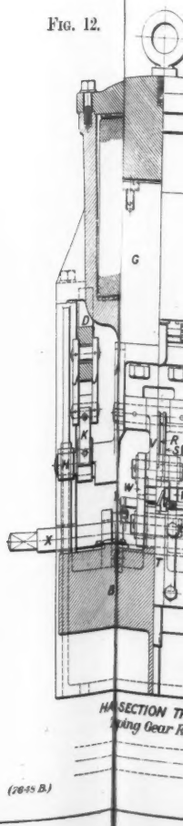


Fig. 12.



HA SECTION T
ting Gear

OR EXTRA HIGH TENSION CIRCUITS.

LLE AND CO., LIMITED, ENGINEERS, HEBBURN-ON-TYNE.

Description, see Page 438.)

FIG. 9.

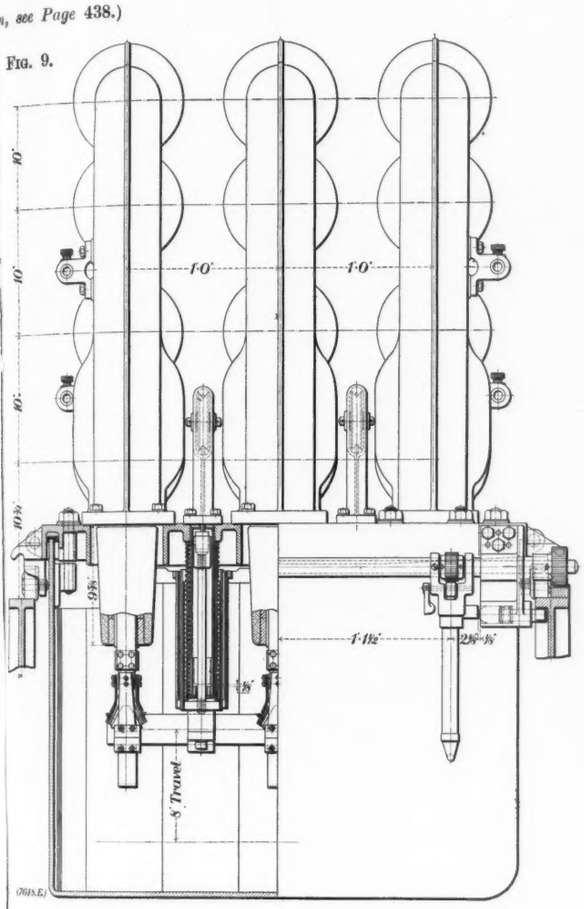


FIG. 18. Bottom of Alternator Terminals.

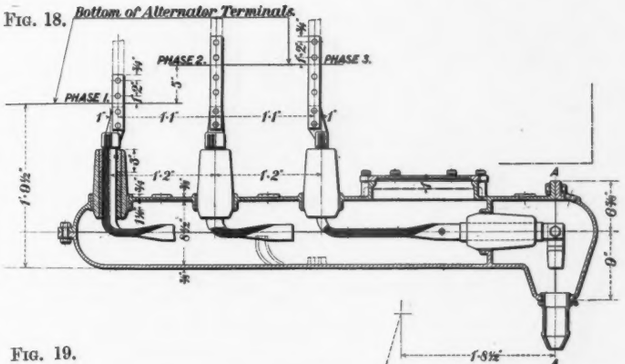


FIG. 19.

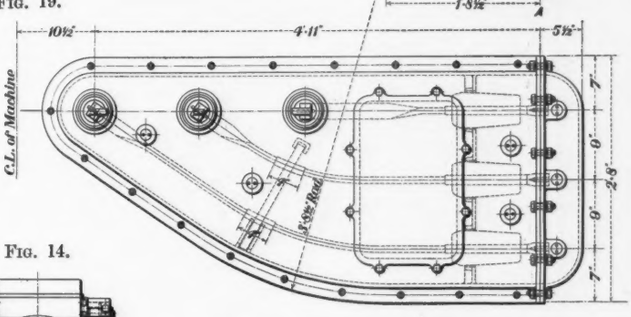
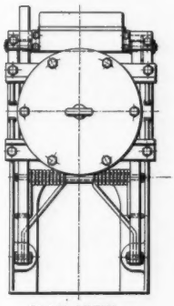
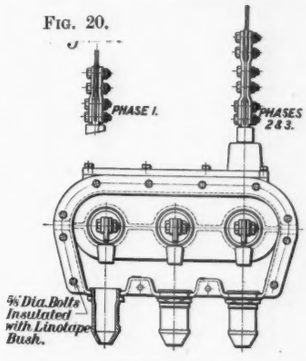


FIG. 14.



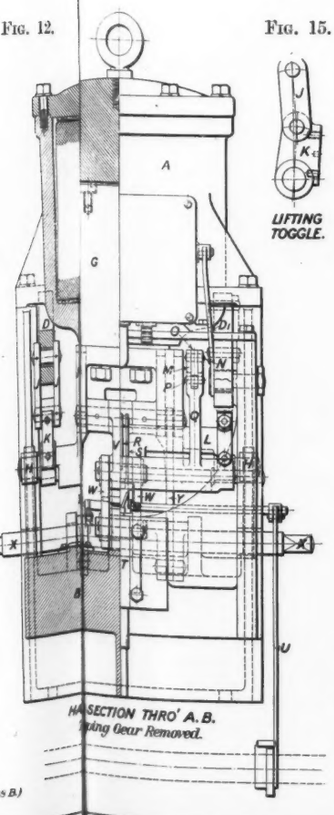
PLAN VIEW OF CONTROL GEAR.

FIG. 20.



SECTION THRO' A-A.

FIG. 12.



SECTION THRO' A.B. Tripping Gear Removed.

FIG. 15.

LIFTING TOGGLE.

FIG. 16.

HOLDING UP TOGGLE.

FIG. 17.

TRIPPING TOGGLE.

FIG. 13.

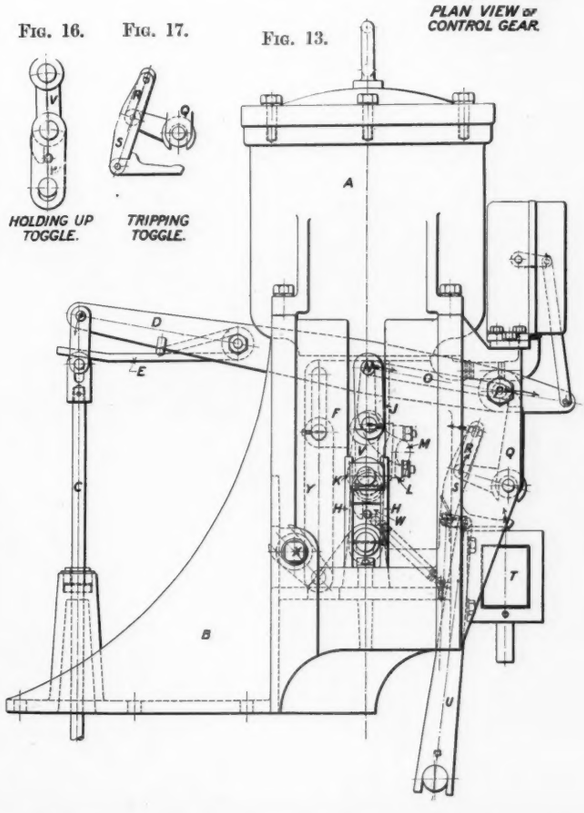


FIG. 21.

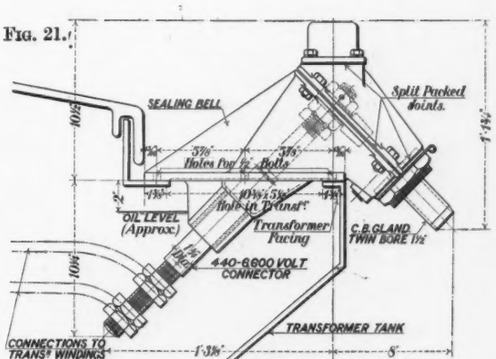
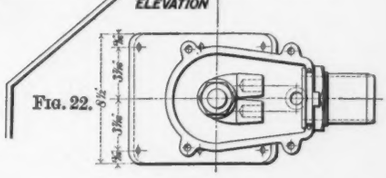
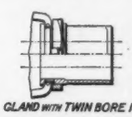


FIG. 22.



(7044.F.)

FIG. 23.



GLAND WITH TWIN BORE 1¾" DIA.

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Two-Page Plate.—IRONCLAD SWITCHGEAR FOR EXTRA HIGH-TENSION CIRCUITS.

ENGINEERING.

FRIDAY, APRIL 6, 1923.

MARINE REDUCTION GEARS.

THE discussion on "Mechanical Gearing" at the recent meeting of the Institution of Naval Architects brought into renewed prominence a standing bone of contention between the engineer and the metallurgist. When a novel application of his products is to be made the metallurgist is apt to demand that the engineer shall specify certain laboratory tests and leave the rest to him. The wise engineer, knowing by sad experience that the suitability of a material for any desired end can only be decided by actual experience, refuses to accede to this request, and the metallurgist feels hurt accordingly at having to do business with a man who is unable to say specifically what he actually does want. When steel first came into general use for boilers and ships, the registration societies soon found that the specification of laboratory tests was far from sufficient to ensure the delivery of reliable material, and despite strong protests from makers, found it necessary to bar certain methods of manufacture, thus trenching on a province in which the metallurgist of that day felt he should rule supreme.

Laboratory tests, however, can never be accepted as a substitute for experience. At one time a certain modified Wöhler test was advocated as a sufficient insurance for the endurance of steel, but it was found that certain phosphoric steels showed up excellently in this test, although like the "brittle intellectuals" from whom we suffered during the war, they were, in service, apt to "crack beneath a strain." Neither fatigue tests, nor the Izod test, nor the repeated blow test invented by Dr. Hatfield can, in the absence of experience, show that a material is suitable for any novel application. At the best such tests may be accepted as affording sufficient grounds for the tentative adoption of a new material, or for the use of an old material for a new purpose, but the only conclusive test is that provided by actual service.

A very striking illustration of the unreliability of laboratory tests is afforded by the history of 25 per cent. nickel steel. This showed wonderful ductility, and apparent toughness, and gave exceptionally good results in notched bar tests. Indeed, so far as the laboratory experiments went it seemed to have every desirable property, but as is well known, it proved most disappointing in actual use. This alloy was supposed not only to be peculiarly tough, but to be also rust resisting. As applied to turbine blading, however, it failed in both particulars, and was rapidly discarded and replaced by what, as gauged by laboratory tests, appeared to be a much inferior material.

It is only after experience has shown that a material is suitable for specific applications that laboratory tests can be taken as proof of adequacy, but they then degenerate into mere acceptance tests, and the simplest and cheapest which will ensure that the material is up to standard, are those which it is expedient to adopt. In certain cases the ordinary tensile tests are as satisfactory for this purpose as the fatigue tests which Dr. Smith advocated as being much more rational.

The metallurgists who took part in the discussion at the Institution of Naval Architects claimed that such failures as had occurred were in the main due to the steel being subjected to stresses it was never intended to withstand. It might, however, be asked, how does the metallurgist know this? There are, in fact, very many cases in which the engineer does not know the maximum stress to which his materials are subjected in service. For example, no one knows the highest stress a motor car axle has to carry. Hence, whilst it is quite possible that certain pinion steels have been more severely stressed than the metallurgist likes, this does not show that the engineer has been making unreasonable demands. It is the engineer and not the metallurgist who is the user of the material, and most engineers want, as Admiral Goodwin pointed out, a steel which will give satisfaction without extraordinary care in manufacture and in use.

By taking special precautions it might be possible to build bridges of tool steel, and in fact Captain Eads did something of this kind fifty years ago, when he adopted for the St. Louis Bridge a chrome steel which could not withstand the ordinary workshop treatment of structural iron. Most engineers have, however, found it preferable to use for bridges a steel which will take without serious injury a reasonable amount of punishment, both in the workshop and in service. No doubt hard steels are successfully used in some very trying conditions. A notable example is provided by the ordinary ball bearing in which is violated one very important mechanical principle of great generality. This was embodied by the late Professor John Sweet in the maxim that mechanisms that can't wear out of shape won't wear much, and it is, indeed, this well-recognised principle which makes it highly improbable that the suggested use of softer steel for pinions will result in very heavy wear.

Though constructed in flat contradiction to this maxim, the ball bearing gives extraordinarily good service. This is due to an astonishing accuracy of form and to the very high quality of the materials employed. He would, however, be a bold man who would expect equally good service from ball bearings having balls of, say, 9 in. diameter. The mere change in dimensions introduces certain factors which make it exceedingly doubtful if ball bearings of such large sizes would give anything like as good service as the ordinary ball bearings do in current practice. Hence the excellent records of hardened gears in motor car work constitute but a poor argument for the use of similar materials in really large gears.

Captain Onyon claimed that special steels could be successfully used in straightforward double reduction gears, but the accuracy of workmanship necessary seems to constitute this a "Rolls-Royce" solution of the reduction gear problem. The immediate requirement of the day is, however, some means of dispensing with the necessity for this extreme accuracy in manufacture and maintenance and to secure satisfactory service with ordinary workmanship and ordinary care. The proposals

made by Sir Charles Parsons and his colleagues at least give promise of such a solution, and the prospect is the brighter in that their suggestions are the result of a study of the actual behaviour of gears in service and do not rest on mere laboratory tests.

Some speakers prophesied trouble or even disaster, asserting that with softer steels the wear would be excessive, and the evidence of Mr. McLaren to the contrary, which was based on actual experience, was thus particularly welcome. There is certainly no good reason for anticipating this, since there is no tendency for helical gears to wear out of shape, and by Professor Sweet's principle there should accordingly be but little wear. Moreover, the abrading stresses are low. In an article published in our issue of October 15 last, it was shown that assuming a uniform distribution of the load, the abrading stress in the gears of which particulars were given in Commander Tostevin's paper three years ago, ranged from 5,500 lb. to 10,140 lb. per square inch. With a plastic steel, there is as Sir Charles Parsons pointed out, every reason to believe that a reasonably uniform loading may be secured, but with a hard steel having a high elastic limit, local concentrations of load cannot be so readily relieved, and before fair adjustment is achieved the bending stresses may mount to a dangerous figure. It would be very interesting to have full particulars of the experimental gear in which Sir Charles found this plastic adjustment in progress, in order that the abrading stress might be computed and a comparison made with theory.

Other speakers criticised the introduction of an elastic element into the gear-box. In past years, Sir Charles has so often had his proposals condemned out of hand by other engineers, that he must by this time be pretty well hardened to adverse criticism. In the early days the steam turbine itself was condemned root and branch, but the outcome has been the disconcerting of the critics, and there was a repetition of the same story when the turbine was introduced into the Navy. No doubt the proposal to introduce an elastic element into the gear-box constitutes an experiment, and will not be definitely adopted until practical experience has shown its real value. Sir Charles has, however, almost formed a habit of making successful his departures from current engineering practice, and the results of sea service with the two experimental gears now being fitted will be awaited with very great interest.

THE ECONOMIC AND INDUSTRIAL CONDITIONS IN AMERICA.

FROM August, 1914, America dates the enormous changes in her economic relationships with the other countries of the world which raised her from a debtor to a creditor position. It is unnecessary to re-state the incidents of that period, which increased the foreign demand for American produce and manufactures, and produced a heavy disturbance of the international trade balance. The entry of the Americans into unaccustomed markets during the war may affect permanently the export activities of other countries, but European traders are now endeavouring to win back their pre-war share of the world's business, and on the success of those efforts depends, very largely, the future happiness and prosperity of their populations. Increased and cheapened production is imperative if the European nations are to recover their shares of export trade. Without greatly reduced costs, recovery is either impossible or will only be attained by a gradual process extending over a long period of time. Business cannot be resumed as easily and as quickly as it was given up at the time when every effort had to be focused on saving civilisation, and the re-establishment of industry in any country under the hampering conditions operating at present, must be a slow and tedious process.

Recently the Department of Overseas Trade published a report by Mr. J. Joyce Broderick, Commercial Counsellor to the British Embassy at Washington, on "The Economic, Financial and Industrial Conditions of the United States of America in 1922," as one of their regular series of trade reports. It provides detailed information regarding the position attained by America during the European War and shows to what extent it has been maintained.

In the American fiscal year ending June 30, 1914, it was estimated that there was an adverse balance in the international trade account amounting to ten million dollars. The principal items in such a balance sheet are, of course, imports and exports, but there are some "invisible" items which can only be gauged by estimating. The invisible items on the one side of the statement include such matters as the interest payable on foreign capital invested in U.S.A., the expenses of American citizens residing or travelling abroad, remittances sent out of the country by immigrants and others, and the sums due to foreign countries in respect of shipping freights, insurance premiums and for other services. On the other side of the account estimates must be made for interest payable on American capital invested abroad and for fresh capital borrowings. The American exports exceeded the imports in 1914 by 470 million dollars; in addition, gold and silver were exported to the extent of 70 million dollars, and when the disparity between the invisible items was accounted for, it required the export of 10 million dollars to balance the account. In this estimate the invisible items were calculated by the foremost economists. The true adverse balance was small enough to permit of easy adjustment without undue disturbance of the rate of exchange.

Just after the start of the European War the imports declined slightly but recovered in 1916, and from then showed a steady increase until the beginning of the year 1921. A heavy increase was shown in the exports from the very beginning of the war which continued until the end of 1920, and resulted in an enormous excess of exports, attaining 4,000 million dollars in the calendar year 1919. In the seven and one-half years from the outbreak of the European War to the end of 1921, the United States exported merchandise, silver and gold to an aggregate value of 20,000 million dollars, which was not offset by imports of goods but was left to be liquidated by the invisible items normally present in the international balance and by emergency financing of various kinds. Among the emergency measures were the loans extended by the U.S.A. Government to the Allied countries, purchases of foreign currency to obtain supplies for the American Army in Europe, credits on account of sales of surplus war supplies and European relief, and the advances of the War Finance Corporation in aid of American export trade. Two other expedients which affected the situation were the repatriation of American securities to prevent embarrassing depreciations in the Allied exchanges and the sale on the American markets of the internal obligations of foreign countries and foreign municipal, industrial and other issues.

The net pre-war indebtedness of the United States to foreign countries under the head of interest in the invisible account has now been permanently reversed and the balance of interest charges in future shows an annual sum, estimated at between 100 and 150 million dollars payable to the United States. Even with shipping payments this credit item does not balance the other items in the invisible account, namely, tourist expenditure and immigrant remittances, and America is thus still a debtor on the invisible account. If the slate were otherwise clean, the necessary excess of exports over imports of merchandise would amount to nearly 400 million dollars to liquidate the invisible indebtedness. That amount must be increased by the net outflow of capital, for only by the continuous export of capital can the export trade of the U.S.A. be maintained on anything like the volume required by the enormous expansion of industrial production which was seen during the war in the United States. Active developments are being made by American commercial associations to find new and enlarged export markets for surplus production. The handicap of depreciated rates of exchange, preventing the purchase of American goods by firms in foreign countries, cannot fail to affect the development of American export trade, and with the trade depression in many countries it has prevented the continuance of business in many lands where there was undisputed entrance during the war.

The iron and steel industries in America were greatly affected by the industrial slump of 1914, and, at first, the outbreak of the European War increased the depression and at the end of the year the plants were working at only 40 per cent. of their capacity. The recovery started towards the end of 1915 and continued throughout the period of the war. Enormous advances in prices were obtained and the highest point was reached in July, 1917, when the average price per ton of iron and steel products represented 370 per cent. of the pre-war figure. The European War orders were not entirely responsible for this advance. Demands dropped continuously after the cessation of hostilities and the production of iron ore during the calendar year 1921 was the lowest on record for 17 years, and just under three-quarters of the blast furnaces were idle. Large unfulfilled orders enabled the United States Steel Corporation to keep its plants running with a good percentage of activity, but many of the independent concerns had to curtail their operations, and some had to close down altogether. The production of steel ingots increased steadily during the first six months of 1922 and reached in May over 3,000,000 tons per month, a figure much in excess of the pre-war average. The plant extensions made during the war are estimated at something over 40 per cent. and put the capacity for producing ingot steel up to 52½ million tons per annum. The industry is overbuilt and capital and overhead charges must be excessive unless an increase occurs in export shipments of steel and steel products sufficient to keep the plants working at their normal capacity percentage. Consolidation of steel interests to reduce costs of production are taking place and others are in contemplation.

Motor vehicle production in the United States attained its highest point in 1920, when the estimated value was over 2,000 million dollars. In that year the exports reached nearly 300 million dollars, of which 51 per cent. was exported to the British Empire as a whole; one-tenth of the total export being sent to the United Kingdom. Endeavours are being made to cut down the importation of European cars, and a memorandum was presented last year to the House of Representatives by the National Automobile Chamber of Commerce, claiming that American manufacturers can compete with European makers with regard to power, price and the finish of completed vehicles.

Mass production methods in the production of machine tools and machinery generally of types for which there is an extensive domestic market, have made foreign competition in the American market almost negligible, while a large export business has been built up to absorb the surplus. Little development has taken place, however, in the manufacture of machinery for which there is a small domestic market, or which is so complicated that standardisation of parts is difficult and skilled labour forms a high percentage of the cost of production. European manufacturers for those reasons hold the American markets for lacemaking, embroidering and certain other classes of textile machines.

The export of American locomotives shows a tendency to shrink back to the pre-war volume. In the year 1920, 1,711 locomotives, valued at nearly 54 million dollars, were exported. The figure had fallen in 1921 to 1,012 locomotives, valued at 34 million dollars, which is in excess of the pre-war figures to the extent of over 700. The general shortage throughout the world kept the value up. The export to Europe has been greatly reduced, and in the first seven months of 1922 the total export to all countries was almost down to the 1914 figures.

In textile machinery America lacks a wide domestic market for cotton mules and gets almost her whole supply from Europe, and mainly from Manchester. British combing machines have been imported to a considerable extent. Since 1914 the delays in deliveries by British makers of textile machinery has had an important effect in strengthening the position of the American manufacturers. With a change in the present demands on the British producers, the effect will probably disappear. In the woollen and worsted machinery field the United States have not succeeded in attaining the high quality of the British product, but are making some headway with the light type of mule.

In the sphere of electrical manufactures and appliances, a prominent feature in the organisation of the three largest companies, General Electric, Westinghouse, and Western Electric, is the attention and expenditure they bestow on research work. In the Western Electric research organisation there are no less than 1,575 physicists, chemists, engineers, draughtsmen and clerks, whose services are entirely devoted to original investigation and development work. A 13-storey building of 400,000 sq. ft. of floor area is used for the work. The exports of electrical goods amounted, in millions of dollars, to 25½ in 1914, 103 in 1920 and 98 in 1921. During the last 18 months the industry has gone through a period of depression because of its main reliance on the demands made by activity in other lines of manufacture, but current reports indicate an increase in the sale of electrical appliances at the present time.

The average year's production of tonnage built in American shipyards before the war was about 445,500. In 1919 it had attained 6½ million tons, but has since rapidly declined, and it is impossible to gauge how the shipbuilding industry of U.S.A. will fare in the future. On June 30, 1921, about 50 per cent. of the vessels owned by the U.S. Shipping Board were tied up, later the percentage was increased, but a reduction followed, and the position was only slightly better in the middle of 1922. The Shipping Board is carrying on its work with net operating losses of about 4½ million dollars a month.

The trades unions had a great accession of strength in the period of the European war and were able to keep the wages rates higher than the increase in the cost of living shown by the index figures. With the acute depression that started about midsummer of 1920 their membership was considerably reduced, and the question of "open shop" working came to the front. Organised labour is hampered in its activity by the extreme left wing and by the lawless camp followers whom it is unable to control. The conditions in that respect are thus very similar to those we know in the Old World. Strikes have been not infrequent and have had the same damaging effects on industry that have been experienced in Europe.

WIRELESS VALVE PATENTS.

THE first patent action officially reported this year, relating to two patents for three-electrode valves, presents several points of interest from the technical standpoint, and also in view of the fact that the case dealt with the new provisions in the Patent Laws that relief could be granted in respect of individual claims of the patent.

The first patent in suit, which has been referred to as the Round patent, numbered 28,413/13, contains three claims, of which the one relied on by the plaintiffs, namely, claim 3, reads as follows —"A vacuum tube containing a hot filament, a grid formed as a closed cylinder completely surrounding the filament, and a third electrode in the form of a cylinder surrounding the grid, substantially as described."

The second patent on which the action was brought is known as the Peri patent, No. 126,658. It contains three claims, of which the first reads :— "A vacuum apparatus intended to serve as relay or generator of maintained oscillations, in which the filament, the grating and the plate are concentrically arranged and fixed directly to the wires serving as conductors, these wires being sealed in the same glass tube soldered to the opening of the bulb, the filament placed at the centre of the system being stretched between two conductors having a certain elasticity, and the grating formed of a spirally-rolled wire supported by its two ends, the plate being cylindrical and surrounding the two other elements, the said plate being attached to its conductor by one or two hooks."

The plaintiffs claimed that both patents were infringed, and although the defendants admitted manufacture of a considerable number of thermionic valves, they denied infringement, alleged invalidity, and pleaded that in part the manufacture had been undertaken as agents for the Government.

In support of the plea of invalidity many references to earlier specifications were made and to sundry publications in literature. In addition, they raised a plea that has recently become of prominence in certain patent actions, that the claim was so ambiguously worded that its extent could not be seen. At the trial, on behalf of the plaintiffs, it was contended that, although several forms of detectors had been known before the date of the patent, including the De Forest three-electrode valve, Round discovered that the grid in use before the date of his invention had not the power to attract all the electrons through it and control them when they reached the plate. Prior to the date of Peri's specification it was said that all the wires for the electrodes were brought in through the glass at different parts, and Peri's method of introducing them through a single neck almost halved the cost of the valves.

For the defendants it was suggested that De Forest's patent directly anticipated that of Round, and that Peri's specification merely covered a design. Some argument took place as to the exact construction that should be put on the patents. In this connection one point is of particular interest, namely, that referring to the word "closed." The plaintiffs contended that the word "closed" in Round's patent meant electrically closed as distinct from physically or geometrically closed. The defendants contended that the anode as well as the grid must be in the form of a closed cylinder completely surrounding the filaments and that their grid, which was a loose, open-ended cylinder, was not in that form. The learned Judge held that the word "closed" was used not in the sense alleged by the plaintiffs, but had its ordinary meaning.

This appears to be one of those cases, therefore, in which the ordinary person reading a specification would obtain the true construction, whereas a highly-trained scientist might find difficulties as to the meaning of the words which would not be present to the layman or one not so highly skilled.

In his judgment Mr. Justice Lawrence very thoroughly considered the state of the art at the date of the patents dealing with the Fleming two-electrode valve of 1904, the third electrode of De Forest in 1908, and Von Lieben's specification of 1911. He then held that, having considered all these matters, the construction of Round's specification did not present any substantial difficulty, and that it was clear that Round, whilst desiring to preserve the benefit of Von Lieben's invention, wanted to improve upon it by constructing the grid and anode in the form of cylinders, which, by surrounding the filament, would interpose a physical obstruction between the filament and the glass, and thus shield the latter from electrification.

For this and other reasons he came to the conclusion that Round intended to emphasise that the cylinder forming the grid must completely surround the filament, yet the anode need not necessarily be made in the form of a closed cylinder, all that is required being that it should be cylindrical in shape and should surround the sides of the grid.

As to Peri's specification, the Court held that the invention described is one relating exclusively to the particular shape and arrangement of the different parts constituting the effective elements of a three-electrode valve of the Audion type, and that on the true construction of the specification it covered only an extremely limited field. Peri does not claim that the various parts which he describes in detail will produce any novel result or will function in any way differently from the same parts as usually arranged in valves of this type.

The Judge compared the alleged infringing valve with the claims of the Peri patent, and found that these claims did not include that valve. It was, therefore, held that, as regards the Round patent, claim 3 was valid, but, having regard to the construction placed on the word "closed," the defendants' valve did not contain such grid as was claimed and was, therefore, not an infringement. As to the second patent, again, although the patent was valid, it did not include the defendants' valve.

After the decision a long argument was raised on the question of costs of the action, in part because only one claim in the Round patent was substantially tested. According to the Patent Acts which were in force prior to 1919, invalidity of one claim would affect the whole patent, and it was commonly the practice, therefore, to attempt to upset a patent on the broadest claim, although, if the patent were good, even a more limited claim might be infringed.

Under the Act of 1917, claims as regards invalidity may stand independently of one another, and relief be given if one be infringed, provided it is valid, irrespective of the validity of the other claims. The position as regards costs, therefore, becomes difficult, and those inventors who are likely to have patents containing claims of doubtful validity would do well very carefully to consider the arguments raised and the judgment given in the above case. As a summary, the plaintiffs were ordered in this action to pay the general costs, including those relating to the issue of infringement, this being set off by the defendants paying the costs of the issue of invalidity.

FUEL ECONOMY OF MOTOR-CAR ENGINES.

FEW engineering designs and manufacturing propositions have had attention paid to them in any degree comparable with the motor car engine. The reasons are apparent to all. A sturdy, reliable piece of plant must be constructed to the exacting requirements of a public who know little or nothing of the limitations involved. The designers must produce an engine which will work efficiently over a great range of speed, have a considerable capacity for acceleration, be comparatively free from noise, be economical to run and have its parts so related to each other as to make them easily accessible for adjustments or replacements. In addition and, indeed, the major consideration of all, the first cost must be low. In a paper on "Petrol Engines," read before the North-Western Branch of the Institution of Mechanical Engineers recently, Mr. A. T. J. Kersey discussed many of these requirements and the limitations imposed on the designer in their attainment. After reviewing the elimination of noise, the causes and effects of vibration and the means of obtaining flexibility of running, the author of the paper discussed the vital questions which are engaging the attention of automobile engineers at the moment, namely, fuel economy and the reduction in the weight of the engine and the space it occupies.

Statements of consumption in miles per gallon he said frequently give totally misleading ideas of the efficiency of the engine, however useful they may be for comparative purposes from a commercial point of view. The number of miles run per gallon is inversely proportional to the total resistance to the motion of the vehicle. There are three factors in this, the first of which is a function of the weight, the second is dependent on the square of the speed and the projected area of the front elevation of the car, and also the form of the body, while the third takes account of the gradient of the road. As the speed and the gradient are increased the total resistance will increase and the consumption in miles per gallon diminish. The only direct method of dealing with fuel consumption that is available to the public, that is assessing it in miles per gallon, may because of these many varying factors, give quite erroneous ideas of how well or ill the engine is running. The reputations of car manufacturers in respect of fuel economy are in the hands of the motor users who love to make "adjustments" without giving much consideration to the factors that might have caused the unusual consumption. The fact that many car engines are not worked at high thermal efficiencies after such changes is manifest to the pedestrians in large towns, who are provided with strong evidence of the presence of unburnt fuel in the exhaust gases of passing vehicles. There is insufficient recognition of the fact that fuel cost is only one item in the cost of running a car and that it only amounts to about one-fifth of the total. Adjustments for its expected reduction may at the best give a negligible return for the trouble and usually, when made by the owners, are productive of considerable losses. It has often been said that the modern proposals of the use of high compression pressures and high speeds of running are warranted by the improvement in fuel economy, but it seems probable that the

proposals would never have become so popular if the taxation of cars were not on a basis of cylinder bore.

The general tendency in design to-day is, of course, to higher speeds of running, and the average increase in engine speed since 1913 is of the order of about 30 per cent. While the common fuels we use to-day remain the only ones available fuel economy is a matter of importance. The conservation of resources is imperative. With the extended development of the use of alcohol and possibly heavier fuels than those in popular demand to-day, the position may be entirely changed. With cheap fuel available in quantity, with a system of taxation more in keeping with the circumstances of motor traction, there would be an entire change of outlook on the engine question.

THE REYROLLE IRONCLAD SWITCH GEAR.

THE attention of those who regard central station practice from the standpoint of outsiders is directed principally to the increase in size of generating units and the tendency towards higher voltages of transmission which have marked recent progress. It is often forgotten, however, that every development along these lines, accentuates the difficulties which the switch gear designer has to face, and the safe control of the enormous amounts of power which are handled by large central stations presents problems quite comparable with those involved in connection with any other part of the undertaking. A dead short circuit on a feeder, which is a possibility always to be contemplated, may mean that hundreds of thousands of horse-power of machinery have to be prevented automatically and in a small fraction of a second from pouring their energy through the fault, and if one endeavours to realise the difficulties of interrupting or diverting the mechanical energy equivalent to that of the electrical power which has to be controlled, the stresses to which the switch gear is subject will be apparent.

In the earliest days of electrical engineering, the flat switchboard of slate or marble, as still used for small powers and low voltages, with its simple switches, was adequate, but the possibilities of this type were soon outgrown. The first great advance was due to Dr. Ferranti, who invented the cellular type of board, the obvious merits of which brought it into very extensive use in this country. For many years it had the proud record of never being associated with a fatal accident, and so far as we know this record still holds. The cellular principle soon found its way into switch-gear design in every country, but the old Ferranti board was unsuitable for the control of large amounts of power, and the next development was along the lines of switch gear operated by electric motors or solenoids and controlled by an attendant at a distance. Such distance-controlled switch gear was largely developed by American designers. The switches, with their brickwork, or concrete, walls between the phases, took up so much room that they had to be housed in a separate part of the building, and the operator merely had charge of a small control board, all parts of which were readily accessible so that he could work with convenience and in perfect security should any of the high-tension switches fail in their duty. As regards the lay-out of the switch gear itself, the cellular principle was always in evidence, the bus-bars, isolating switches, potential and current transformers, &c., being always separated by partitions analogous to those of the old Ferranti board. Safety was secured at the expense of space, and space occupied by switch gear is a costly item in a central station.

An appreciation of the growing need for concentrating switch gear into more reasonable dimensions together with the belief that this could be done with even greater safety, by adopting a new principle of construction, led Mr. H. W. Clothier the managing director of Messrs. A. Reyrolle and Co., Limited, of Hebburn-on-Tyne, to the development of the self-contained ironclad gear, various types of which we illustrate on pages 434 and 439, and on Plate XXVII. Instead of relying upon air spaces and brick walls for safety, this feature was secured by completely enclosing all live parts in a strong iron casing, maintained, of course, at earth potential. An ordinary sheathed electric cable is regarded as an unquestionably safe piece of apparatus, although within less than an inch of the hand that is holding it there may be three conductors alive at a potential of 30,000 volts or more. If the conductors of a cable can be confined safely in this way, the bus-bars of a switchboard may be protected in a somewhat similar manner, and though the analogy does not hold completely because a cable has no moving parts and is not required to make or break a circuit, the principle of protection by insulation and earthed armouring can be carried to a good distance even in switch gear. Not only is ironclad switch gear safer and more compact than the alternative cellular design, but as each panel is a self-contained unit, independent of walls or anything else, access and inspection are easily provided for.

The way in which the ironclad principle is applied to actual examples, will, of course, depend greatly upon the size of the switches and the work they have to perform. A panel for controlling a low-tension motor circuit of comparatively small power will be a very different thing from one designed to break the full load of a large-power station at a pressure of 50,000 volts. Yet each embodies the same essential features, the details of design only being modified in accordance with the respective requirements of the two cases. Figs. 1 and 2, on page 434, show front and back views of an eight-panel board to control three-phase circuits at 11,000 volts. The bus-bars are contained in the continuously connected cast-iron casings at the back, and the switches themselves are carried on brackets at the front. Any switch can readily be completely removed for examination when required. This is effected by racking the switch together with its bus-bar plugs along its bearer brackets until it is free from the bus-bars, and then removing it by means of the special trolley furnished for the purpose. When on the brackets, the switch is supported on small rollers—feet running on rails so that it can easily be moved in and out of position. It is moved by means of a small handle on the switch which actuates reciprocating pawls which engage with the teeth of racks fixed alongside the carrier rails. An interlocking device renders it mechanically impossible for the switch to be connected to or disconnected from the bus-bars unless the switch contacts are "open." The photographs referred to make it clear that the board is entirely self-contained with free access to all sides. It is moreover absolutely safe by reason of its ironclad construction, and a workman could handle any exposed part or lean up against the whole structure without the slightest risk to himself, although within a few inches of him there are conductors alive at 11,000 volts.

The same principles of design will be seen to have been embodied in the larger switches illustrated in Figs. 3 and 4, on page 434. The switch proper is mounted on wheels as before, and can be racked into and out of contact with the bus-bars. As soon as it is properly clear of the bus-bar contacts the chambers in which the latter are contained are automatically closed by cast-iron doors which are operated by the withdrawal of the switch. These doors are seen to be closed in Fig. 3. When the switch is returned to its working position, the doors automatically open to allow the contacts to enter. This provision ensures the complete safety of any mechanic who may have occasion to work on the switch while the bus-bars are alive, and it also prevents the entrance of dirt or the inadvertent insertion of things which might cause damage by coming in contact with the live terminals. After the switch has been withdrawn from the bus-bars the switch contacts and other parts may be examined by lowering the oil tank in which the contacts work. In Fig. 3 the tank is shown resting on the ground below the switch. These tanks are made of boiler plate welded at the corners, and vary in thickness up to ½ in. or more in the larger sizes. A considerable thickness of metal is required to give the strength necessary to withstand the great rise of pressure which occurs at the moment of breaking a heavy load. Numerous experiments have been made by Messrs. Reyrolle in this connection, and surprisingly high pressures have been observed under certain conditions. They are, of course, only momentary, and are probably connected with the formation of sound-waves in the oil, but they would be none the less destructive if the tanks did not possess adequate strength to resist them.

The appearance of a switch when removed from the remainder of the mechanism, is illustrated in Figs. 5 and 6, on page 434. The three orifices in the upper part are air vents to allow the free escape of the vapours given off from the oil when the switch is operated. The leaf contacts which form the connection between the switch and the respective bus-bars are clearly seen projecting from the two lower tiers of insulators. The upper set of insulators are not in use, their function being to carry contacts to make connection with an alternative set of bus-bars. It should be noted that all Messrs. Reyrolles' ironclad switches are erected in accurate and substantial cast-iron jigs, so that every switch is strictly interchangeable with every other of the same type and nominal size. Any switch, therefore, can be transferred to any other panel of the board if this should be desired, without any risk of trouble.

A cross-section of a complete panel with switch in position is given in Fig. 7, on Plate XXVII, the panel being of a similar type to that shown in Figs. 1 and 2. The two sets of bus-bars, each set in its own ironclad housing, are seen at the upper part of the back of the panel. The bars are heavily insulated, and the casings finally filled in solid with insulating cement, so that no air space, nor any possibility of dampness or dirt entering, exists. The perfect protection afforded to the contacts by which the switch is connected to the bus-bars is clear from the drawings. The current and potential transformers are arranged in a chamber below the bus-bars, and the respective conductors are then united in the cast-iron end-belt and pass away as a three-core cable.

Figs. 8 and 9 give further details of the construction of switches of two different types. The illustrations are self-explanatory. Fig. 9 shows, at the right-hand side, the ratchet handle and shaft, terminating in a spur wheel at one end, by which the switch is racked into and out of connection with the bus-bars. At the left-hand side can be seen one of the small rollers on which the switch runs out along the frame. One of the strong helical springs by which the required speed of opening of the switch contacts is secured, is shown in Fig. 9. In the Reyrolle design, rapidity of opening is considered as of much more fundamental importance than excessive length of break. To assure this rapidity the moving contacts are made as light as possible, and the weight of the whole moving parts is reduced to a minimum so that there are no serious inertia forces to resist rapid opening.

There are two standard forms of operating gear, namely, hand and electric, which are built as units applicable to any switch. The switch contacts of hand operated gear are always actuated by means of wire ropes, which pass over pulleys as shown in Fig. 9. To put the switch in these ropes have to be pulled against the resistance of the opening springs, and this is effected, when hand operation is used, by the mechanism shown in Figs. 10 and 11.

The operating gear consists of a frame bracket casting A carrying the hand-operating mechanism and trip coil B, with a hinged cover C surmounted by a mechanical indicator D, the whole being arranged for bolting on the top plate of the oil switch proper and for coupling up to the movable cross-bar of same by means of wire ropes running over fixed guide pulleys. The drawing does not show these, but as indicated in the small detail at the side of Fig. 11, the switch levers E are so arranged as to get a toggle effect in the relationship of the rope to the pivotal centre. They are bridged across by the spindle F, the overhanging ends of which take the eyes for the rope. This spindle carries the cylindrical casting G, arms on which bear rollers H through which the closing effort from handle levers J is transmitted, the tripping mechanism interposing. The casting G is kept up to a stop by the spring S.

Pivoted on a spindle bridging across between handle levers J is the clutch arm K which carries on a lever extending downwards the pin P connected through the links L to the main release lever M,

which pivots on spindle N and carries roller R. Clutch arm K also carries pivoted upon it above the centre the trip lever Q which carries a catch engaging with roller R and has a tail extending over a protrusion U from the trip arm T which is lifted when trip coil B is energised, releasing the mechanism by withdrawing the catch on trip lever Q from the roller R. The pressure from the switch kick-off springs is communicated through the rollers H into a tendency to rotate clutch arm K, which, however, is locked by the catch on Q impinging on roller R. The main release lever M with links L forms a toggle system kept short of the dead centre by pin P abutting against the lower side of M, the pressure on roller R being quite small, thus ensuring a light trip. On tripping, withdrawal of catch from roller R permits sufficient rotation of clutch arm K to allow rollers H to free themselves from K, thus permitting switch levers E to fly to the off position, leaving the handle levers J in their original position. These handle levers are locked in the "On" position by the pivoted catch V engaging with the opposing catch on arm W, which is pivoted on the side of frame bracket and held up to a stop by a strong spring. Tripping of the switch causes a pin projecting from spindle N to release V from W.

If it is desired to trip the switch by hand, forcible movement of the handle in an outward direction rocks W, extending the spring, until the abutment on W pushes on a projection fixed to the spindle to which trip arm T is pinned. Fixed to spindle N is the cam plate O which actuates the auxiliary switches shown, these being provided, one to cut out the trip coil after operation and others to suit individual requirements such as indicating lamps and electrical interlocks. The spindle to which tripping arm T is pinned is extended on one side and connected up with a link to interlock it with the switch racking-out mechanism. The hinged cover C is interlocked with the switch levers E to prevent its being raised while the switch is closed. The mechanical indicator D is actuated by a pin projecting from the side of the right-hand switch lever E and it lifts freely away when the cover C is hinged up.

When distance-control of the switches is required, the mechanism illustrated in Figs. 12 to 17, on Plate XXVII, is fitted. This mechanism comprises a powerful short-stroke solenoid A straddling over a framework B, which carries a link motion, the whole forming a self-contained unit for mounting direct on to the top plate of the oil switch proper. The apparatus is coupled up to the movable cross-bar of the switch by means of vertical steel rods C suitably guided and fitted with dashpot portions at their lower ends.

The link motion consists of a pair of side beams D, D_1, pivoted on the framework at one end and attached at the other ends by links to the oil switch plunger rods C, a certain amount of independent movement being permitted by the slot and governed by the intervening springs E. These side beams are lifted directly by the saddle F, carried by the solenoid plunger G, which is guided vertically by slides H provided in the supporting framework B. Interposed, however, are the lifting toggles J, K, which are under the control of the tripping mechanism. The lower members K of the lifting toggles are rigidly bridged across from side to side by the casting L, which carries two arms M, terminating in pins N for links O, the centres of the pins P at the other ends of which coincide with the pivotal centres of the side arms D, but are carried by the arms of the tripping lever Q. This is constrained at the centre of its width by its other arm being coupled up to the inverted toggle tripping link system R, S, and can be released either by energising the trip coil T or through the interlocking link U, which is connected with the switch racking-out gear. The lifting toggles J, K, stop short of the dead centre, consequently a collapsing thrust is taken through the links O to the tripping lever Q, which is locked in by the tripping toggle links R, S, a very light blow upon which is sufficient to release; the black arrows show the directions in which the various parts move when the switch trips out. The action of closing the oil switch takes only a fraction of a second, so that it would be a waste of energy to have the solenoid excited continuously. Immediately the oil switch has closed, the current is cut off from the solenoid, and independent holding up toggle links V, W, maintain the switch closed, but do not interfere with its automatic opening as they are knocked out while the lifting toggle is collapsing.

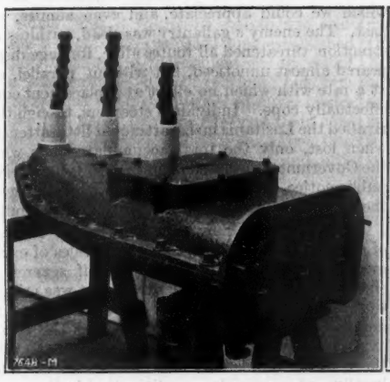

FIG. 24. IRONCLAD TERMINAL BOX.

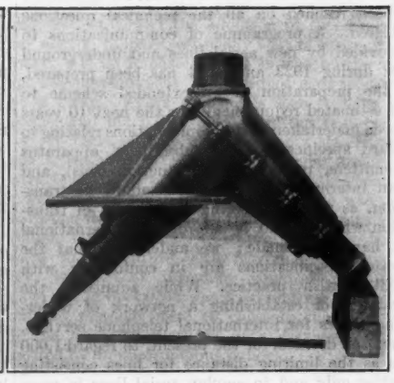

FIG. 25. IRONCLAD SEALING BELL.

The trip mechanism is self-resetting, and the independent movement provided for at ends of side beams D, D_1, is for the purpose of ensuring this by allowing the tripping toggles R, S, to resume their relative position, as well as to obviate any jar. When the solenoid plunger G and saddle F fall, the holding-up toggle collapses, but the lifting toggle is straightened out ready for next operation. A cross-shaft X to take removable levers is coupled up by links Y to saddle F to provide for hand operation when needful, but does not interfere in any way with normal magnet operation. The necessary auxiliary switches for indicating by means of lamps on the control board, the position of the switch, and for cutting out the trip coil after switch has operated, also for any electrical interlocking required, are contained in an enclosed box actuated by side beam D_1.

The ironclad principle which is fundamental to the design of Reyrolle switch gear, is applied as far as possible to other details of power-house equipment. Figs. 18 to 20, on Plate XXVII, show a main terminal box for a 16,500-k.v.a., 11,000-volt three-phase alternator, the design being due to the Yorkshire Electric Power Company. The function of the box is to connect three single-core plain lead-covered cables from the switch panel to the alternator terminals. The general appearance of the terminal box is illustrated in Fig. 24, annexed. The live parts, are, as will be seen, entirely armour-clad. The cable glands which are of the universal type, are insulated from the main casting with a view to the avoidance of circulating currents in the lead sheathing of the single-core cables. Several air outlet holes are provided in the top cover of the box, and the filling chamber affords room for any expansion of the compound due to temperature rise.

A further application of the ironclad principle is shown in Figs. 21 to 23, Plate XXVII, and Fig. 25, annexed. The drawings and photograph represent a sealing bell for mounting on the top of the extension of a transformer tank. The sealing bell is filled with compound, and affords a sound mechanical protection to the conductors inside. The internal leg of the bell terminates below the oil level in the transformer casing. The external leg is fitted with a brass gland through which a lead-covered cable is led away. Expansion of the compound within the bell is provided for by a free space left in the filling chamber at the top. The use of ironclad sealing bells of this type makes it perfectly safe to put transformers out of doors in any climate with no protection of any kind against the weather. It is impossible for anyone to get a shock from them so long as the metal casing is not smashed, and they are also immune from damage due to rain, snow or other conditions of weather. It is needless to point out that the arrangements of transformers out of doors effects very considerable economy in a power transmission scheme, for the cost of an efficiently ventilated transformer house is quite an appreciable item of expenditure to save.

The illustrations and description which we have given of the Reyrolle switch gear are sufficient to demonstrate its essential safety to any one conversant with power station matters. As far as it is humanly possible to protect both the operator and the system from mischance this has been done, and the record of the gear is, we believe, unblemished in respect of serious accidents. In one case a switch rated by the makers at 250,000 k.v.a., had thrown upon it the duty of breaking the circuit when a short circuit occurred on the system comparatively near the power station. There was 38,000 kw. of plant running at the time of the short circuit, and it was estimated that the maximum short-circuit power amounted to 950,000 k.v.a. The switch operated at 3·5 cycles after the action of the relay so that, at the moment of separation of the switch contacts at least 500,000 k.v.a. had to be broken. The oil tank of the switch, which was of the standard boiler plate type, withstood the stress without distortion of any kind, and only a little oil was thrown out by the violent discharge. The only real damage done was the burning of the surfaces of the replaceable sparking contacts, and these, of course, were renewable at a trivial cost.

A feature of the Reyrolle gear which deserves special emphasis is the comparatively small amount of room it occupies in comparison with cellular gear of the ordinary type. The latter requires a great deal of brickwork or concrete constructional work, which is both costly and requires a large amount of room. As in cellular gear, air-spacing is relied on to take up the electric stresses, and the daily variations of the atmosphere call for a high factor of safety; a wide spacing of the conductors is necessary. When the latter are clothed with solid insulating materials and encased in metal, as in the Reyrolle gear, the necessary spacing becomes extremely small, the comparison being somewhat similar to that between an overhead air-spaced transmission line, and a three-phase lead-covered cable. Owing to the reduction in space which the armourclad design involves the switches can be brought very much nearer the control board, with a consequent saving in buildings which is quite important. In many cases the Reyrolle gear has been installed in place of cellular gear for which there was no further accommodation, and the saving in space has enabled many extra circuits to be controlled without any enlargement of the buildings.

NOTES.

THE SUPPLYING OF ELECTRICAL ENERGY.

The dispute between the Birkdale District Electric Supply Company and the Corporation of Southport which was referred to in our notes of July 28, 1922, page 116, reached another stage on the 24th ult., when the Court of Appeal reversed the judgment of Mr. Justice Eve and held that the corporation were not entitled to drive their tramway cars by means of their own electrical energy within the old urban district of Birkdale. The company had the right of supplying electrical energy within their district,

but the corporation maintained that when using their own electricity to drive the cars they were not "supplying" electrical energy within the meaning of the Electric Lighting Acts and were therefore not infringing the company's rights. Mr. Justice Eve, following a judgment of Mr. Justice North in a water case in 1894 (West Surrey Water Company *v.* The Guardians of the Chertsey Union), reluctantly held that "supply" did not mean simply using for oneself as distinguished from supplying to other persons, and he refused to grant an injunction against the corporation. The Court of Appeal pointed out that the judgment in the water case turned on a different Act, and that all the circumstances and provisions were different. As regards the Electric Lighting Acts and Orders, the word "supply" was used in its most general sense, and not in its restricted sense of supplying to a person distinct from the supplier. The court held, therefore, that the corporation were supplying electrical energy and the company were entitled to an injunction to prevent their doing so.

Water in the Atmosphere.

Some of the views which Dr. G. C. Simpson, F.R.S., director of the Meteorological Office, advocated in a discourse, recently delivered at the Royal Institution, were novel, or had, in any case, not previously been exposed by him in so definite a form. The problems of the condensation of aqueous vapour in air, and of water crystallisation, are very complex and not fully understood. Vapour and liquid water can co-exist even at temperatures far below freezing-point, possibly at — 60 deg. C. Water evaporates at all temperatures from solid and liquid surfaces, and from curved surfaces at a more rapid rate than from plane surfaces. The relative humidity over ice would, at — 60 deg., only be 55 per cent. of that over liquid water, however, so that vapour would distil over from water on to ice. Until Aitken's experiments of 1880 it was believed that a moist atmosphere would deposit its water as soon as sufficiently cooled. Aitken showed the need of dust nuclei for the condensation. But Assmann failed to discover any dust nuclei in the mists of the Harz mountains—not contaminated by the dust which falling rain drops would pick up—and A. Wigand confirmed in 1913 Aitken's observation that not all the dust particles of Aitken's dust counter were equally effective. He found that the dust from a beaten carpet and coal dust had little effect, but that smoke, probably owing to the hygroscopic sulphur dioxide in it, was most effective, and he suggested that the chemical and physical adsorptive power of the particles, their curvature, electric charges and the "large ions" of Langevin were factors in the condensation. The hygroscopic character of the nuclei was later emphasised by Hilding Köhler, who studied hoar frost and rime at the Halde Observatory, Norway, determining the sizes of the mist particles and their contents of chlorine, and concluding that the condensation nuclei came from the sprayed sea water. Very small water-drops, Dr. Simpson proceeded, would not freeze apparently; for optical reasons he believed that the iridescent clouds of the high atmosphere must consist of liquid particles, not of ice. The smallest drops, of 0·001 cm. radius, fell at a rate of about 1 cm. per second; as the size increased, the rate of fall increased, but it reached a maximum of 800 cm. per second for drops of 0·25 cm. radius, because larger drops broke up while falling. That bigger masses of water came down in "cloud bursts" was ascribed to vertical upward currents; the moist air was carried up in columns into colder regions until the condensed moisture was hurled over the edge of the column. Hailstones attained their large sizes by being carried up and down repeatedly by vertical currents and gravity; as they passed through atmospheric regions of supercooled water, a layer of amorphous water was deposited on each hailstone, in colder strata ice crystals froze to the hail, which thus showed alternating layers of the two forms of the solidified water. This generally-accepted hail theory of Dr. Simpson's would require powerful ascending air currents; but cloud formation would not be explicable without vertical currents. We may add that the views advanced on condensation would not militate against C. T. R. Wilson's ionic condensation nuclei; for Wilson's experiments higher degrees of supersaturation are required than are assumed to prevail in the atmosphere. On the other hand, steam turbine engineers would be glad to avoid supersaturation in the turbine, as Mr. H. M. Martin first pointed out in our columns.

Long-Distance Telephony in Europe.

As a result, we have no doubt, of the suggestions put forward in Mr. Frank Gill's presidential address to the Institution of Electrical Engineers, which was referred to in a leading article on page 589 of our last volume, the French Ministry of Posts and Telegraphs called a preliminary conference to consider the question of improving international telephone communications in Europe. The conference met in Paris early in March under the presidency of M. Dennery, who is responsible for the research work conducted by the French Post Office, and included representatives from the engineering departments of the Post Offices of France, Italy, Great Britain, Belgium, Spain and Switzerland; the British representatives were Major T. F. Purves, Engineer-in-Chief to the Post Office, Mr. J. G. Hill, Mr. A. B. Hart and Mr. H. G. Trayfoot. The preliminary work of the conference has now been concluded, and it is understood that an agreement has been reached on all the technical questions considered. A programme of communications to be provided by new aerial lines and underground cables during 1923 and 1924 has been prepared, and the preparation of an extended scheme to cover estimated requirements for the next 10 years has been undertaken. Recommendations relating to standard specifications for subscribers' apparatus (transmitters, receivers and induction coils), and for an international reference standard of transmission, as well as covering the degrees of transmission which should be afforded on international lines, have been made; we understand that the suggested specifications are in conformity with present British practice. While admitting the desirability of establishing a network of underground cables for international telephone services, it has been decided, for the present, to regard 1,000 miles as the limiting distance for lines consisting of cables only and to employ aerial lines in cases where greater distances are involved. Repeaters of the thermionic-valve type will be used on both aerial lines and on cables, and special consideration is to be given by the various administrations represented at the conference to the regulations required to protect long-distance telephone lines from disturbance by electric power transmission systems. The appointment of a permanent committee, representing all European countries, for the purpose of maintaining continuous co-operation, and the establishment of a small permanent secretariat to act on behalf of the committee and to facilitate the exchange of technical information, are other items in the recommendations of the conference. These recommendations, we understand, will be conveyed to the postal authorities of the countries represented at the conference, as well as to those of the other European countries, and if approved will doubtless be given effect to. Whatever the outcome of the conference may be, it is of considerable interest and importance in that it will provide the necessary machinery for concerted action to improve existing means of communication between the industrial and financial centres of Europe. If the telephone can be made a reasonably rapid and effective means of conducting business over long distances, we have no doubt that full use will be made of the facilities provided.

LITERATURE.

History of the Great War: Based on Official Documents, by Direction of the Historical Section of the Committee of Imperial Defence. Seaborne Trade. Vol. II. *From the Opening of the Submarine Campaign to the Appointment of the Shipping Controller.* By C. Ernest Fayle. London: John Murray. 1923. [Price 21*s.* net.]

Two years ago (January 21, 1921) attention was called in our columns to the first volume of this work, which told how plans matured with purpose and deliberation had enabled the nation to meet the early effects of the conflict on the sea. We were reminded of the policy of leaders and of the action of shipowners and sailors, which enabled British finance and commerce to sustain, albeit at heavy loss, blows which might have proved disastrous if not parried by precaution and frustrated by courage and patriotism. In this volume, the tale of sacrifice and devotion is carried further, and the gloomy story of the national difficulty and danger assumes a graver tone, as month after month goes by, piling up the appalling list of loss and disaster. The history of the middle period coincides in time with the growth of the sinister force, latent in the practically untried submarine, whose virulence increased daily but had not yet exhibited all the baleful effects of which it ultimately proved itself capable. The period closes at the end of 1916, when the Shipping Controller was appointed, or at a time perhaps better marked in the well-remembered history, when Mr. Asquith resigned the office of Prime Minister.

The time was critical, success was seen to be far off, if attainable, strenuous effort was demanded and freely given by all, and tales of individual heroism and endurance were absorbed in the life struggles of a nation. The excitement of running down surface raiders pursuing legitimate tactics which we could appreciate, and even admire, had past. The enemy's gallantry was dead, ruthless destruction threatened all routes alike, tonnage disappeared almost unnoticed, but without parallel, and at a rate with which no effort at replacement could effectually cope. Individual steamers, though they rivalled the Lusitania in size attracted little attention when lost, only the total accumulated loss which the Government declared from time to time received public notice, and of this aggregate we failed to grasp the magnitude as an index of impending calamity.

The author will not, or cannot, relieve his story of exertion and continual menace by tales of excitement or heroism. He limits himself severely to showing the extent to which transport was crippled by enemy action, and that notwithstanding the demands for tonnage grew greater, as the volume available grew less, the claims were met, and that the country fulfilled its engagements to the allies, loyally and generously—qualities that in these later days seem to be overlooked in certain quarters. Neither does he see it his duty to criticise the action of the Admiralty and naval authorities by the light of subsequent knowledge: his task is to tell simply what did happen, not to point out alternatives that might have proved more successful, however much such details might add to the piquancy. The collection of facts exhibits great industry, and the arrangement a consummate mastery over details; the careful examination of the many interests involved permits the whole panorama of transport to be drawn in its true perspective, and yet the tale hangs heavily at times. A depressing similarity in the history of the successive months is noticeable; it requires relief. Without departing from the strictly historical narrative, Mr. Fayle might have permitted us to see more of the development of the submarine, about which curiosity is morbidly acute. The air of profound secrecy that has been jealously maintained has surrounded this weapon with a mystery that invites penetration. Lack of knowledge and unwise concealment have added to the terrors of its deadly attack, and of the devices prepared to counter its elusiveness we know little. Now that there is no longer any necessity for secrecy, legitimate curiosity might be satisfied in some measure, justice might be done to ingenuity that was continually on the alert to outwit the stealthy movements of submarine craft, but we learn little or nothing of the effectiveness of the many experiments, and perhaps there is little to be learnt, for the deep sea holds its secrets well.

When the story opens in the early part of 1915, the German cruisers and armed liners were practically *hors de combat*, and the advent of the submarine was affecting the character of naval warfare. The struggle was becoming a war of attrition, and if Great Britain could preserve her trade and draw upon the entire resources of the world, exhaustion must sooner or later overtake Germany. Hence a new weapon was required which would cripple

Britain's command of the sea, and the Germans saw in the submarine the means of accomplishing their aim, more especially as its destructiveness and power of mischief had not been ascertained and there was no control or limitation to its movements and behaviour by international agreement. The submarine was a law to itself, and Germany abused this freedom of action without compunction, though this weapon must possess great and legitimate advantages for attack. Shipping was liable to assault at the point of greatest concentration. Scouting was shifted from outlying routes where the chances of collision were few, to the main arteries of British commerce at their most vulnerable points. Also no supply ships were needed to carry fuel, for the submarine was most effective near its base. When threatened with attack, the craft could disappear under the surface, and the motive power was not exhausted by a long chase. Against these manifest advantages, however, it may be recalled, that this form of vessel could not properly exercise the right of a belligerent to board and search vessels on the high seas without undue risk, and to sink ships at sight on suspicion of carrying contraband was contrary to international law. Still less was it possible to provide for the safety of passengers in captured liners, and to claim that their obligation was fulfilled by allowing non-combatants to leave in the ship's boats was a mean evasion of an obvious duty. Yet if Germany was to win success, it was necessary to disregard long-established usage, and to assert a determination to adopt measures unsanctioned by conventions, but rendered necessary as the consequences of novel modes of warfare. On these lines they framed their conduct, which, as we know, finally led them into conflict with the Great Western Republic and ultimately compassed their undoing.

Such were the weapons and such the policy pursued, that aimed at destroying the commerce of this country, and sought to compel neutrals to withhold their assistance, while depriving the allies of the advantages which they enjoyed from the maritime supremacy of Great Britain. It cannot but be admitted that the attack had the more favourable position, though for long the danger and loss lay less in the enemy's actual achievements than in the possibilities of future development. For in addition to the inconvenience due to direct attack, our transport service was hampered by the decrease in carrying power for commercial purposes, by the continual demands of the naval and military authorities in the form of requisitions, by the urgent solicitations of the allies for transport, by the redistribution of trade routes, and by the congestion at ports, both at home and abroad. The avoidance of routes where submarines congregated, led to the substitution of longer for shorter voyages, or a reduction of the number of voyages in a given time, while the congestion at ports, never constructed or intended for the accommodation of the enormous traffic suddenly thrown upon them, meant delay in turning round with a consequent reduction in the annual carrying power of the tonnage employed. Moreover, many steamers were taken for hospital ships, and in the case of the Eastern Mediterranean, during the Gallipoli campaign, as these were not under the Red Cross Flag, the fastest steamers had to be selected in order to secure immunity from the submarine attack. Nevertheless, owing to the seizure of German and Austrian ships at sea, and in British ports, and to the output of new steamers, Mr. Fayle is able to report that nine months after the beginning of the war, the tonnage available for all purposes was appreciably in excess of that on the Register at the outbreak of war.

This advantage could not long survive, for the larger the number of ships afloat the greater the opportunity for the submarine. The autumn of 1915 brought such a heavy loss that at the end of twelve months of war, the total aggregate loss was estimated at more than 13,000,000*l.* The wisdom of the State Insurance Scheme was then amply demonstrated. Without such support individual owners and merchants must have been crushed, and these, dragging down others in their fall, might easily have precipitated a crisis fatal to the free flow of seaborne trade. As it was, difficulties with the Exchanges were becoming apparent, and troubles were thickening. It was desirable to force up the Exchanges against Germany and weaken her purchasing power, but equally desirable to maintain our own. This could only be done by maintaining British exports at the highest possible level to neutral countries, and considerable leakage into Germany was the consequence. Export restrictions could easily be more injurious to ourselves than the occasion of loss to the enemy. The factors to be considered are very complex, and it is the great merit of this work, that the author handles the details in a lucid and masterly fashion. The relations with neutrals were always fraught with danger, but troubles at home were equally conspicuous. The inequalities in the incidence of requisitioning led to jealousy; and specialisation in the loading and unloading of ships, however necessary, was the cause of much heart-burning. The coasting traffic especially suffered, both from requisitions and the cost of insurance, but especially from the decision of the Government to prohibit any advance in railway rates. Larger problems occupied the Government in the monopoly of the Australian and New Zealand supplies, and the "Bunker Control," which brought pressure to bear on steamers under neutral flags in which German capital was beneficially interested. These ships were practically immobilised if the bunkering firms could be persuaded to withhold fuel at the Atlantic depots. A very efficient restriction of enemy trade followed the adoption of this policy. Other neutral tonnage, especially that of Spain and Norway, was so important that it was unwise to adopt any measure that would reduce it or tend to drive it away. Every problem is seen to have a converse, and much has been forgotten that confused the issue or determined action. Mr. Fayle treads a clear path through the tangle, and reconstructs the history of the period with a sure hand. The worst has not yet been told, the time was to come when tonnage disappeared at the rate of a million a month and the stoutest heart looked forward to the future with fear and trembling. Every device that ingenuity could suggest or courage put in operation was tried and was needed, if our old methods were to compete successfully with the scientific methods of a General Staff, supported by an unscrupulous public.

Aircraft Steels and Materials. By Brigadier-General R. K. BAGNALL-WILD and others. London: Constable and Co., Limited. [Price 16*s.* net.]

THOSE who were in charge of the testing and acceptance of material for aircraft during the war had a unique opportunity of finding out all the ills that such high-class material is heir to, both in the raw and in the finished state, not only because they were dealing with unprecedentedly large supplies but also because both supplier and user were in many cases without experience of any other material than mild steel. It was with the idea of placing such valuable experience in the hands of those who could utilise it that a series of lectures were arranged to be delivered in Sheffield by those men who were prominently connected with the aircraft problem during the war. As Professor Ripper says in his preface it is "important that the experience obtained during the war and the fruits of the researches carried out during that period should find suitable and permanent expression, and at the same time be made available for the use of a wider audience than was possible when the lectures were delivered."

The collected addresses in book form are very attractively published, and they contain more of the stuff that makes successful engines than any book on the same subject yet printed. In the opening chapter by Brigadier-General Bagnall-Wild, it can be seen that he was ever calling for improvement with simplification, and there is no gainsaying that it was this commonsense outlook that fostered our success in the building of aircraft by ensuring the requisite material supply. And reading his contribution again brings back memories of hair line cracks, impact tests and slag inclusions which have changed for long enough now from being the torturing horrors of our harassed past into the mildly interesting and wholly unexciting problems of our dispassionate present.

On the subject of drop-forgings the second chapter is most informative and is quite the best introduction to the subject which we know of. To the uninitiated the production of a stamping is always something of a mystery, but the step from ignorance to an appreciation of the technical details should not now be attended with the slightest difficulty.

Case-hardening steels in aircraft engines as in motor engines form an important class, and there is much rubbishy material sold under fancy trade names as case-hardening steel which is not even decent ordinary mild steel. There is unfortunately still something in the make-up of the successful steels used for case-hardening which does not show in the analysis, and so long as this exists then so long will steels be sold by brand and not by specification by people who think they have discovered the secret. Mr. Thain points out many of the defects which arise during manufacture of both the steel and the finished part, and he also gives some very useful tables of the properties of steels used for case-hardening after different heat treatments. A wide variety of compositions are available from which the tensile strength of the core in its tough condition can be obtained with any value between 26 tons and 90 tons per square inch. There are numerous uses in engineering practice for these high-quality case-hardening steels, whenever their properties become better known among engineers.

Of course, it must have been often asked by engineers why the numbers of steels and specifications are multiplied until it becomes confusing to make a choice, and why it is necessary to use an expensive steel when exactly similar results can be obtained from a commoner material. In certain cases, for instance, a steel with 0·45 per cent. carbon will give as high a tensile strength, as high an elongation and a better impact test than a nickel-chrome steel costing between two and three times as much, and to anyone not acquainted with the conditions it would appear wasteful to use the expensive steel in engine production. But there are other sides to the question and reasons why one steel will not do for every purpose, and in the final chapter of this book the late Mr. Remington discusses these issues in clear and concise terms. If we have any criticism to make, it is merely that such an important chapter from the point of view of policy might well have been placed second instead of last in the order of arrangement.

Trustworthy and informative, this book should be studied well by everyone concerned in the manufacture of internal-combustion engines.

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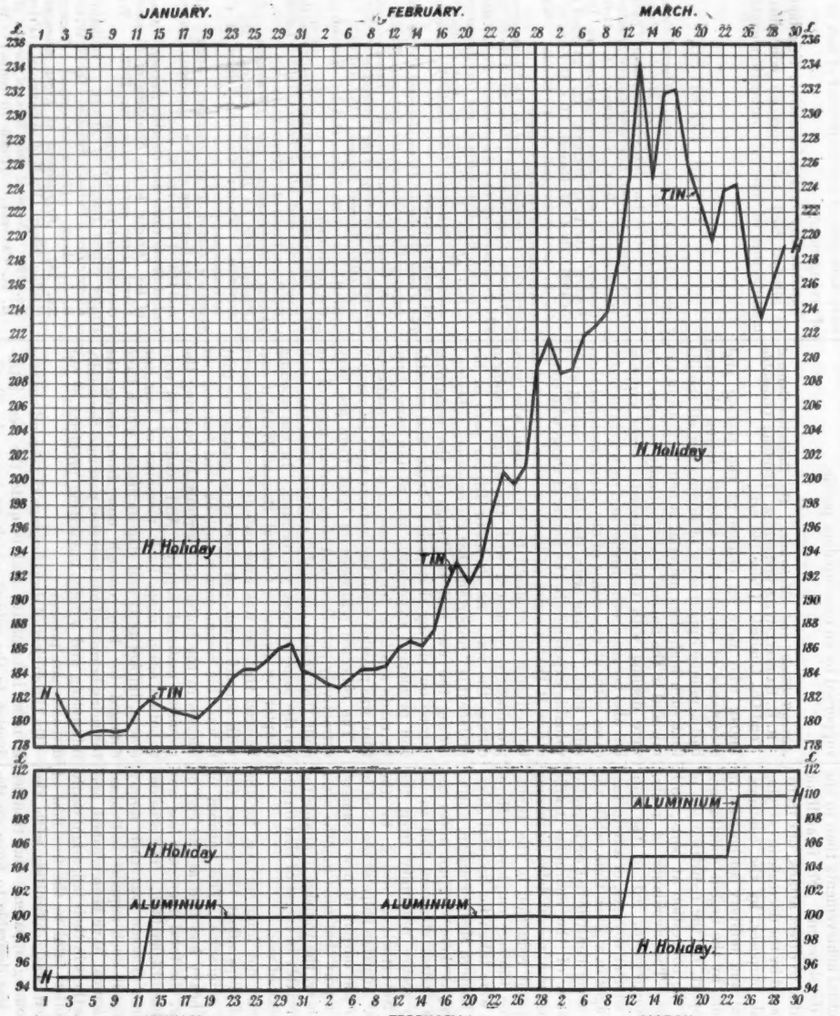
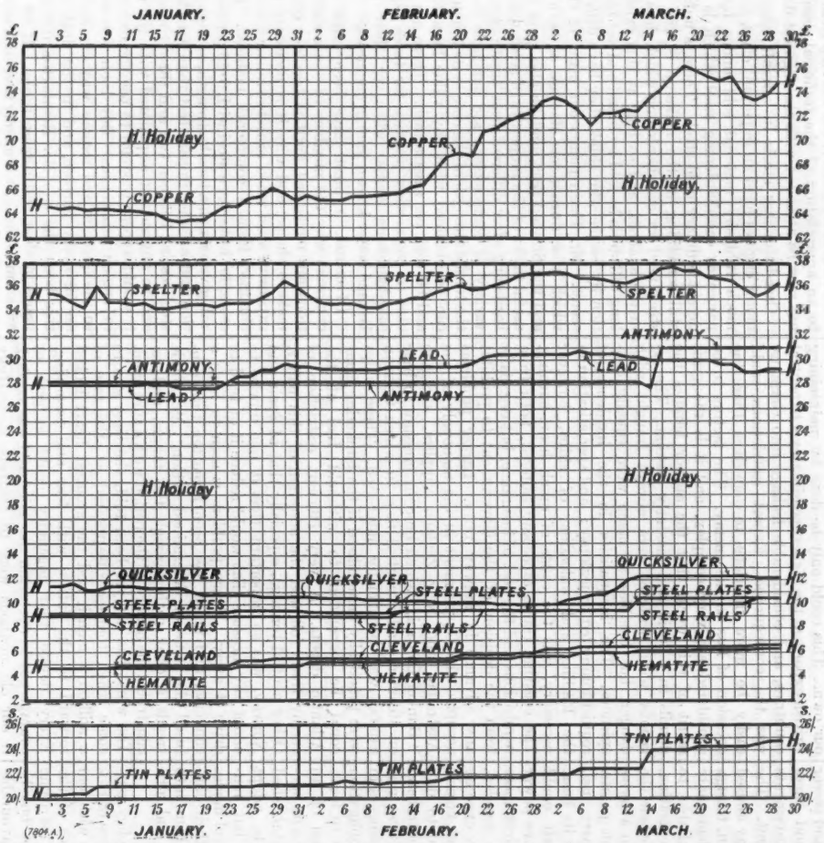
DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN THE PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)





NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lbs. to 80 lbs. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

ENLARGEMENT OF FLOATING DOCKS IN SWEDEN.—The Eriksberg Engineering Company and Shipyard is about to add another section to its floating dock No. 3, whereby the capacity will be increased from 10,000 tons to 14,000 tons. The enlargement of the floating dock outside the Göta yard, Gothenburg, by one-third, is also contemplated; this is, so far, the largest floating dock in Scandinavia, the capacity being 12,000 tons. When enlarged, its capacity will be 16,000 tons.

RECORDING MINE SHAFT SIGNALS.—The Prevention of Accidents Committee of the Rand Mutual Assurance Company, Limited, Johannesburg, Transvaal, offers prize money not exceeding 250*l.* for design or designs of the most practical device for recording shaft signals, &c., on the mines. The device must be capable of making a permanent record showing clearly and separately: (1) The time and nature of all signals received by the driver: (*a*) from underground, (*b*) from the bank. (2) The time and nature of all signals given by the driver: (*a*) to underground, (*b*) to the bank. (3) The conveyance or compartment (if any) to which the signals mentioned in (1) and (2) refer. (4) The time during which each conveyance is in motion. It is stated in addition that whilst it would be an advantage to have a device recording the speed and direction of the motion, this is not essential. Entries close on September 30, 1923, and must reach, on or before that date, Mr. J. F. Bilbrough, Managing Secretary, the Rand Mutual Assurance Company, Limited, P.O. Box 413, Johannesburgh, Transvaal, S.A.

The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which heavy sections.

Secretary, the Rand Mutual Assurance Company, Limited, P.O. Box 413, Johannesburgh, Transvaal, S.A. prize money not exceeding £50, for design or designs of the most practical device for recording shaft signals, &c.,

THE RANAREX CO_2 RECORDER.

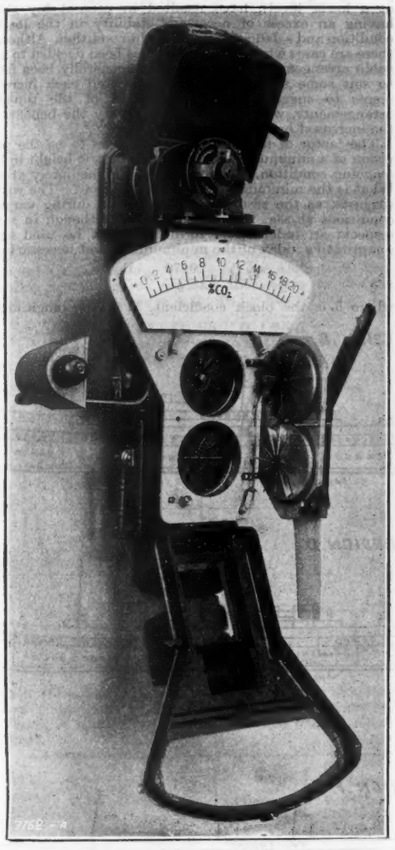


FIG. 1.

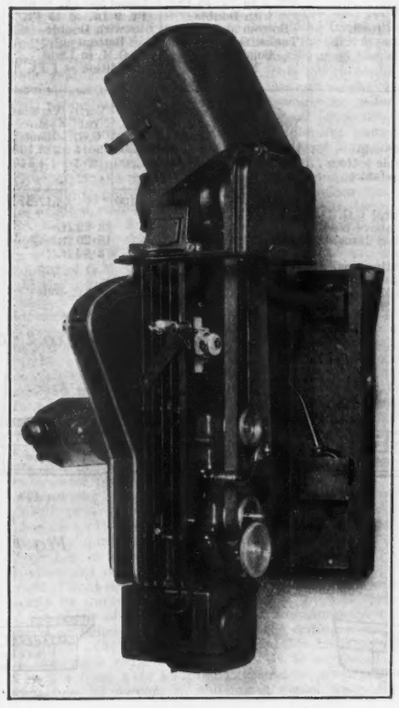


FIG. 2.

Fig.3.

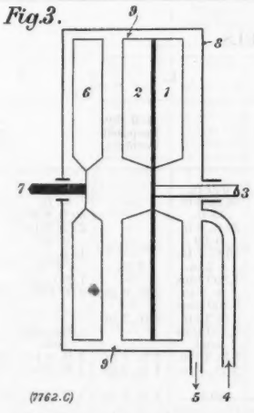
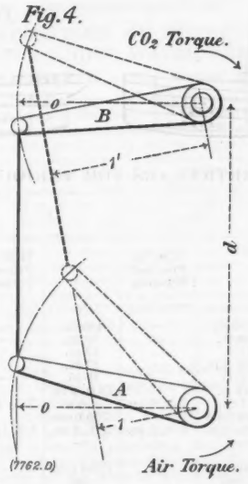


Fig.4.



MANY of the CO_2 recorders on the market suffer from the practical defects that they are delicate in construction and require continual attention, thus being unsuitable for the working conditions of boiler houses or other places where they are required to operate. For certain duties they often have a further drawback, namely that their indications are delayed by 10 minutes or more, so that they fail to give the observer a true reading of the condition of the gases at the time of observation. This time-lag is fatal to their use in connection with the testing of the carburetter adjustment of motor car engines, a duty for which they would otherwise be well fitted, since it is generally agreed that the mixture providing complete combustion with the minimum of air will give the maximum economy and practically the maximum power. In the Ranarex CO_2 recorder, which is illustrated in Figs. 1 to 4, on this page, this time-lag is practically absent, and the instrument therefore serves the purposes of the motor car tester as well as those of the engineer who is concerned with the composition of flue gases from boiler furnaces.

The instrument, which is of Continental origin, is of unusually substantial construction, but it is also notable on account of the principle upon which it works. It is entirely mechanical in its action, and neither uses any chemicals not does it embody any delicate electrical or other devices. Its essential parts are two fans which are kept in rapid rotation by means of a small electric motor at the top of the instrument. These fans are shown in Fig. 1, and the way in which they are driven by a belt from the motor can be seen in Fig. 2. The fans run at the same speed, each in its own chamber. In the chamber, adjacent to each fan is a disc with vanes, which is so mounted that it tends to rotate owing to the friction of the air or gas set in motion by the vanes of the driven fan. Its tendency to rotate is proportional to the density of the gas in the chamber, and this fact is taken advantage of to determine the percentage of CO_2.

The arrangement will be understood from Fig. 3. A gastight chamber 8 is provided with a gas inlet 4 and a gas outlet 5. Inside the chamber is a duplex impeller, the right hand side of which 1, draws in gas from the inlet and expels it by the outlet. This impeller is driven by the motor already mentioned. The left-hand side 2 of the impeller gives a whirling motion to the gases in the chamber and as a result a torque is transmitted to the recording fan 6. The magnitude of this torque depends jointly on the density of the gas in the chamber and on the square of the speed of the impeller. One chamber is filled with flue-gas or exhaust gas, as the case may be, and the other with pure air, so that as the speed of the impellers is the same, the torques transmitted to the recording fans will vary with the densities of the gas and air respectively. These two fans are coupled together by levers A and B, which are joined by a link, as shown in Fig. 4. The length of the link is less than the distance between the fan centres so that the effective length of the levers varies according to their position, as indicated in the diagram. The recording fan in the air chamber is connected to lever A, and the fan in the gas chamber to lever B. When the impellers are running, therefore, the lever system will take up a position in which the torque of the air fan balances that of the gas fan, and the pointer connected to the system will then indicate on the dial the percentage of CO_2 in the gases which determines this position.

The forces which determine the position of the pointer are comparatively large so that the instrument is sturdy in construction and positive in its indications. The exhaust gas is filtered and cooled down to the air temperature, so that its density as compared with air shall be dependent entirely upon its composition, temperature effects being eliminated. As cooled exhaust gas is always saturated with water vapour, arrangements are made that the air used for comparison shall be similarly saturated. Owing to the high velocity with which the gases under test are forced through the instruments, the latter has a time-lag of only 20 seconds or 30 seconds, which is quite short enough to enable the instrument to be used for testing the exhaust gases of motor-car engines for the purpose of making carburettor adjustments. It is, in fact, largely employed for this purpose in certain foreign motor-car factories. With a mixture which is too weak, such as one containing for example, 20 per cent. of air to petrol by weight, oxygen will be present in the exhaust gases to the extent of about 6·5 per cent., and CO_2 to the extent of only 10·5 per cent. Diminishing the air supply reduces the excess oxygen and increases the CO_2, until when 15 per cent. by weight of air only is admitted the excess oxygen has vanished and the CO^2 content has risen to 14·5 per cent. This is the most economical adjustment. Any further increase in mixture strength results in a rapidly diminishing amount of CO_2, and the presence of unburnt H and CO in the exhaust. A reduction of the air to 10 per cent. of the weight of the petrol, diminishes the CO_2 to 7·5 per cent. and shows hydrogen present to the extent of 5·5 per cent., and carbon monoxide to the extent of 11·5 per cent.

The adjustment of the Ranarex recorder can be checked at any time by running both chambers with pure air, when a zero reading should be obtained. It is claimed that the accuracy of the instrument is within one-tenth of 1 per cent., and this accuracy is unaffected by variations in the speed of the fans between 2,500 r.p.m. and 3,500 r.p.m. The power taken by the driving motor is approximately 40 watts. The instrument is made both indicating and recording. It is handled in Great Britain by Mr. R. T. Durran, of 76, Victoria-street, London, S.W. 1.

METAL CORROSION IN WATER.—In two independent papers on the "Corrosion of Iron and Steel in Water," published in *Industrial and Engineering Chemistry* R. E. Wilson, of the Massachusetts Institute of Technology, and F. N. Speller and V. V. Kendall, of the National Tube Company, Pittsburgh, come to the conclusion that the main factor in the corrosion is the amount of oxygen present in the water. Many factors come in, temperature, composition of the water, rate of water flow and the formation of surface films, which may be hard and protective or spongy and non-protective and some physical chemists still consider the concentration of the hydrogen ions of the greatest importance. The workers mentioned, however, point out, not for the first time, that this concentration is not decisive. The hydrogen is deposited on the iron, and forms a polarising gas film; the hydrogen may subsequently be liberated as gas, or it may be depolarised by the oxygen, and the latter is generally the most important reaction. That has long been recognised by technical men who decarate or deactivate the water to make it less corrosive. In some of their results Speller and Kendall do not agree with the previous work of Heyn and Bauer and of Friend; with whom they are otherwise in accord. Much depends on the special conditions. Speller and Kendal varied their rate of water flow between 0·0043 ft. and 8 ft. per second, and they suggest determining the amount of oxygen in the water by the Winkler method after having cooled the water by means of a coil placed near the intake, where corrosion is always worst.

THE INFLUENCE OF FORM UPON THE STABILITY AND PROPULSION OF PASSENGER SHIPS.*

By JOHN ANDERSON, Member.

AN examination of the Transactions of this and other kindred institutions shows that while the forms of merchant vessels have been discussed at great length with regard to propulsion, the discussions on stability have been, until recently, largely confined to methods of measuring metacentric heights, the range of stability due to freeboard, the effect of free surface, the influence of bilge keels, and so on.

Some remarks on the points which particularly interest the writer, with regard to stability, appear in the paper read to this Institution by Mr. L. Peskett in 1913; also in the paper delivered by Sir John Biles in Paris last year. The former suggested that "the G.M. in the seagoing condition should be the minimum commensurate with safety," while the latter suggested that large passenger ships should be designed for "at least a foot of G.M. in the light condition." It was stated that the second proposal contained a margin which would allow for reasonable additions being made during the construction of the vessel. The balance between these extreme conditions is dependent upon the amount of cargo carried in relation to the total volume of the vessel and on the vertical disposition of the cargo, fuel and fresh water, and it is thought that, generally, the two opinions which have been quoted would be in conflict when applied to the large vessels of to-day, which are designed primarily for the carriage of passengers. The present slump in freights has shown that passenger ships may be required to proceed to sea without any cargo whatsoever, and as many modern ships can only do so when weighted with sand or other ballast (in addition to their water ballast), it is thought that the design of hull, to meet all recent developments, should be reviewed.

Half a century ago, the practice for moderately high-speed vessels was to make the breadths of about one-tenth of the length, a common belief at that period being, I understand, that speed could not be obtained economically if the breadth exceeded this proportion. These ships were deep in relation to their breadth, and the only erections imposed upon their structural decks were the necessary entrances and the master's house. The chief characteristics of their forms were V-shaped sections at both ends and a very high rise of floor, and both of these features somewhat assisted stability in the light condition, although they did not provide an adequate amount, and the vessels had to be further assisted by special dispositions of cargo when loaded, and by the introduction of large quantities of sand or other ballast when returning without cargo.

Since that period developments have been continuous and rapid in the direction of increased superstructure and freeboard, extra deck equipment, redisposition of structural material, and the adoption of forms which are beneficial for propulsion, but detrimental to stability. Breadth has been greatly increased to meet these developments, but the alterations in design, in conjunction with the larger percentage volume which is utilised for passenger space (which has the effect of placing the cargo at a lower level), have resulted in present-day ships having an excess of necessary stability in the loaded condition and a deficiency in the light condition. Although there are cases where the breadth has been decided to suit cabin arrangements, its amount has generally been fixed to suit some standard for stability, and each increase seems to suggest further extensions of the top-side arrangements, which may largely nullify the benefits of the increased breadth.

The factor of first importance appears to be the provision of a minimum amount of metacentric height in the seagoing condition, and the question immediately arises, What is the minimum for such a condition? The writer suggests, as the results of observations during varying conditions at sea, that the following, although in some respects an indefensible formula, might be used as a quantitative index of the minimum amount necessary:—

$$G.M. = \frac{0{\cdot}70}{b} \times \frac{R}{A}$$

where b is the block coefficient, R is the longitudinal vertical area above the waterline, and A the longitudinal vertical area below the water line. It will be understood that the results given by the foregoing formula might not provide sufficient stability in a damaged condition. This contingency would require separate consideration and would generally be dependent upon the internal arrangements of the vessel.

To obtain the ideal amount when loaded, some designers have been prepared to accept dimensions which would yield a neutral or even a negative G.M. in the light condition, while others have chosen a positive G.M. when light, and sought to obtain a damping effect in the loaded condition by the introduction of anti-rolling appliances: the addition of such appliances may greatly increase the cost and weight of a vessel, and are therefore objectionable.

Obviously a G.M. of, say, a foot in the light condition cannot in itself be considered sufficient for a vessel of, say, 66 ft. breadth, as such a vessel would be unduly sensitive

TABLE I.—*Ballast Conditions of Passenger Ships designed for a Fixed Amount of Deadweight.*

Item.	Vessel 550 Ft. × 66 Ft. 3 In. × 45 Ft. with Double Bottom and Deep Tanks. G.M. in Light Condition = Neutral.			Vessel 550 Ft. × 67 Ft. 9 In. × 45 Ft. with Double Bottom only. G.M. in Light Condition = 1 Ft.		
	Tons.	Vertical C.G.	Vertical Moment.	Tons.	Vertical C.G.	Vertical Moment.
Light ship ..	10,150	30·2	306,520	10,300	30·4	313,100
Double bottom ..	1,800	2·3	4,140	1,800	2·3	4,140
Deep tanks ..	2,100	15·0	31,500	—	—	—
	14,050		342,160	12,100		317,240
Vertical C.G. above base ..	24·35 ft.			26·22 ft.		
Ballast draught ..	20·90 ft.			18·20 ft.		
G.M.	3·55 ft.			3·60 ft.		
Righting moment (displacement × G.M.)	49,880 ft.-tons			43,560 ft.-tons		

Fig.1. DESIGN.A.

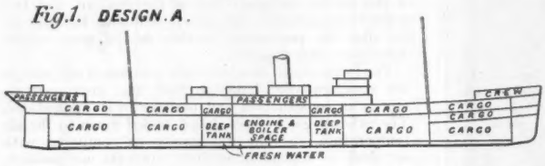


Fig.2. DESIGN.B.

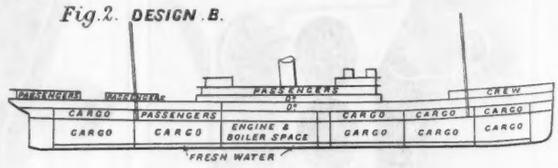


Fig.3. DESIGN.C.

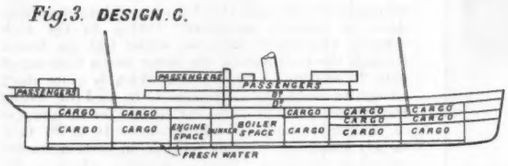


Fig.4. DESIGN.D.

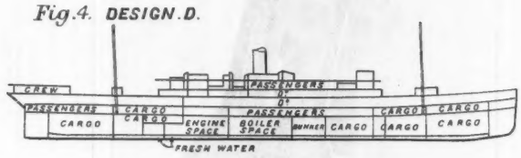


Fig.5. DESIGN.E.

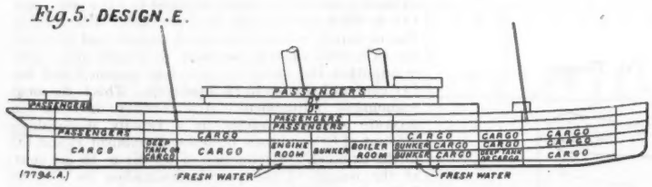


Fig.6. DESIGN.F.

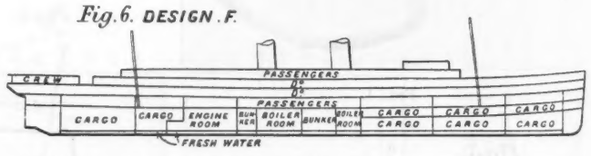


TABLE II.—STABILITY PARTICULARS FOR VARIOUS TYPES OF VESSELS.

Designation.	A.		B.		C.		D.		E.		F.	
		G.M. by Proposed Formula.		G.M. by Proposed Formula.		G.M. by Proposed Formula.		G.M. by Proposed Formula.		G.M. by Proposed Formula.		G.M. by Proposed Formula.
Length	450 ft.	—	470 ft.	—	430 ft.	—	440 ft.	—	550 ft.	—	500 ft.	—
Breadth	56 ft.	—	56 ft.	—	57 ft.	—	56 ft.	—	66 ft. 3 in.	—	62 ft.	—
Depth	35 ft.	—	40 ft.	—	32 ft.	—	38 ft.	—	45 ft.	—	39 ft. 6 in.	—
Load draught	28 ft.	—	27 ft. 6 in.	—	27 ft.	—	26 ft. 4 in.	—	28 ft. 6 in.	—	23 ft. 6 in.	—
Block coefficient at load draught	0·73	—	0·71	—	0·65	—	0·66	—	0·69	—	0·52	—
Light draught	11 ft.	—	13 ft.	—	13 ft. 6 in.	—	13 ft. 10 in.	—	16 ft. 7 in.	—	19 ft. 2 in.	—
G.M. in light condition	4 ft.	3 ft. 6 in.	1 ft.	3 ft. 6 in.	+ 6 in.	3 ft. 6 in.	−2 in.	3 ft. 1 in.	+ 2 in.	3 ft.	+ 10 in.	2 ft. 7 in.
Weight of water ballast in double bottom	1,350 tons	—	900 tons	—	750 tons	—	960 tons	—	1,800 tons	—	1,000 tons	—
G.M. in ballast trim	4 ft. 11 in.	3 ft. 1 in.	2 ft. 9 in.	3 ft. 2 in.	2 ft. 3 in.	2 ft. 11 in.	2 ft.	2 ft. 8 in.	1 ft. 9 in.	2 ft. 6 in.	2 ft. 10 in.	2 ft. 2 in.
Weight of water ballast in deep tanks	1,900 tons	—	—	—	—	—	—	—	2,100 tons	—	—	—
G.M. with total ballast	4 ft. 2 in.	2 ft. 6 in.	—	—	—	—	—	—	2 ft. 10 in.	2 ft. 2 in.	—	—
Weight of fuel	1,250 tons coal	—	1,060 tons coal	—	1,900 tons coal	—	2,200 tons coal	—	2,450 tons coal	—	1,000 tons coal	—
G.M. with total ballast and fuel	2 ft. 6 in.	2 ft. 2 in.	1 ft. 11 in.	2 ft. 10 in.	2 ft.	2 ft. 3 in.	2 ft. 8 in.	1 ft. 9 in.	3 ft. 10 in.	1 ft. 6 in.	2 ft. 4 in.	1 ft. 11 in.
G.M. loaded with cargo, fuel, stores and fresh water at start of voyage*	8 in.	8 in.	1 ft. 3 in.	11 in.	1 ft. 10 in.	1 ft.	2 ft. 4 in.	11 ft.	2 ft. 7 in.	1 ft. 2 in.	2 ft. 7 in.	1 ft. 9 in.
G.M. at finish of voyage with fuel, stores and water consumed*	+ 9 in.	1 ft.	+ 11 in.	1 ft.	+ 7 in.	1 ft. 8 in.	+ 3 in.	1 ft. 8 in.	10 in.	1 ft. 7 in.	1 ft. 4 in.	2 ft. 2 in.

NOTE.—Allowances have been made in the ballast and fully loaded conditions for free surface in fresh-water tanks.

* The G.M.'s in these two loaded conditions are estimated on the assumption that the cargo spaces are filled with homogeneous cargo.

* Paper read at the Spring Meetings of the Institution of Naval Architects, March 23, 1923.

to changes; for instance, the emptying of a double-ended boiler in the wings would give the excessive inclination of, roughly—

$$\frac{50 \text{ tons} \times 20 \text{ ft.}^1}{10{,}100 \text{ tons} \times 1{\cdot}0 \text{ G.M.}} = 0{\cdot}10 = 6 \text{ deg.}$$

A vessel must therefore be assisted in such a condition by ballasting and this raises the question:—Is it better to provide for additional water ballast in deep tanks in conjunction with reduced breadth for ballast seagoing trim than to design for, say, a foot of G.M. when light (which would give a greater excess than at present when loaded) in association with ballast in the double bottom only? The figures in Table I illustrate the effect of these alternatives and suggest to the writer that deep tanks are preferable to increased breadth, provided they are always available for use; also that they are now necessary for providing sufficient ballast when the double bottom is used extensively for the carriage of oil fuel and fresh water.

The subdivision arrangements proposed at the International Conference for vessels of less than 0·50 permissible factor appear to lend themselves to designs embodying deep tanks, as is shown by Fig. 5 (Design E).

Fig.7. ***VESSEL 550'.0" LONG.***
Full Lines are Original Form.
Dotted Lines are Proposed Form.

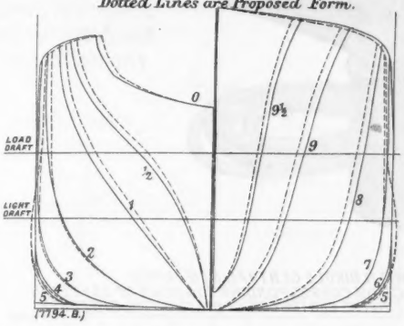


TABLE III.—*The Influence of Form upon the Stability and Propulsion of Passenger Ships. Particulars of Vessels of 6,450 Tons Cargo Deadweight and 15 Knots Speed.*

—	E. Original Vessel E, Without Deep Tanks.	G. As Design E, but with Beam Increased to Obtain Proposed G.M. in Ballast Condition Without Deep Tanks.	H. Vessel to Proposed Form to Obtain Desired Stability in Loaded and Ballast Trim.
Length	550 ft.	550 ft.	550 ft.
Breadth	66 ft. 3 in.	68 ft. 3 in.	63 ft.* 67 ft. 10 in.†
Depth	45 ft.	45 ft.	45 ft.
Hull	8,400 tons	8,570 tons	8,220 tons
Machinery	1,750 tons	1,730 tons	1,690 tons
Light ship	10,150 tons	10,300 tons	9,910 tons
Coal	2,450 tons	2,430 tons	2,370 tons
Fresh water and stores	1,450 tons	1,450 tons	1,450 tons
Cargo	6,450 tons	6,450 tons	6,450 tons
Displacement ..	20,500 tons	20,630 tons	20,180 tons
Shaft horse-power ..	9,000	8,850	8,700
Capacity for water ballast in double bottom	1,800 tons	1,800 tons	1,800 tons
G.M. in light condition	2 in.	1 ft. 2 in.	1 ft. 2 in.
G.M. with ballast tanks filled ..	1 ft. 9 in.	2 ft. 6 in.	2 ft. 6 in.
G.M. with tanks and bunkers filled ..	2 ft. 7 in.	3 ft. 4 in.	3 ft. 5 in.
G.M. loaded at start of voyage	2 ft. 7 in.	3 ft. 2 in.	1 ft. 2 in.
G.M. loaded at end of voyage	10 in.	1 ft. 7 in.	9 in.

NOTE.—The deficiency in G.M. in the arrival condition can be made up by adding water ballast.
* About load-line. † Extreme.

Table II contains data for vessels of different types (the profiles of which are shown by Figs. 1 to 6) under varying conditions of loading, and the alternative figures given in the second column for each type indicate the G.M. suggested by the proposed formula. It will be seen that the intermediate type A, which has a fairly full model, has a reasonably good balance throughout, but in the others, as the superstructures are increased, or as the block coefficients are reduced or the ratio of volume for passengers is increased, there is a deficiency in the light condition and an excess when loaded. It will be noticed that in some cases the amount shown for the arrival condition when loaded is less than the suggested minimum, but these can be increased as necessary by adding water ballast in the double bottom.

Vessel E represents the greatest extreme, but the deficiency in the ordinary ballast condition, or when oil or fresh water is carried in the double bottom, can be corrected by filling the deep tanks. Objection is sometimes raised to the fitting of such tanks, however, since the most economical means of arranging for them gives an unhealthy system of subdivision, and, alternatively, if a rational system of bulkheads is adopted, the spaces necessary for such tanks would conduce to making the adjoining holds too short for the handling of long cargoes.

In view of all the foregoing it is thought that further consideration should be given to developing forms which would better meet the desired conditions for such types of vessels, and it is suggested that if the form of vessel E were modified as shown in Fig. 7, this desire could be obtained, and, at the same time, the cost and weight of the hull, propelling machinery and fuel would be reduced. The figure also shows that it is proposed to reduce the breadth by 3 ft. 3 in. from about the load-line upwards, and from the load-line downwards to increase it gradually up to 1 ft. 7 in. at the light water line.

Table III, the basis of which is a fixed amount of cargo deadweight, gives the comparative particulars for (E) the original vessel E; (G) a vessel of similar design to (E), but 68 ft. 3 in. breadth, and (H) a vessel of the suggested form and dimensions. The extreme breadths for (G) and (H) have been fixed to give the suggested amount of G.M. in the ballast condition. It is estimated that the weight of hull (H) would be reduced by 180 tons compared with (E), due to the reduced width of the top-side structure, and also owing to the reduced displacement at the ends of the vessel. The extra width below the water-line amidships does not appreciably increase the weight, as the reduced scantling of the side frames due to their shape would counterbalance the extra material involved by the additional girth. It is estimated that the proposed underwater form of hull would not involve any additional expense over the ordinary straight form. It is also estimated that the power necessary for a speed of 15 knots would be reduced by about 3½ per cent., due to redisposing the volume at the ends towards the underwater part amidships.

The writer is aware that there may be three possible objections to this proposed modification of form, and these are: (1) The possibility of the vessel being damaged against a quay wall if the additional width when submerged is not known to the docking master. (2) The Government authorities may demand an increased outreach of boat davits, but it is suggested that such increase would be unnecessary considering the gradual increase of the shape of the hull; also that the increased width would be below the water level in the ordinary seagoing condition. (3) The theoretical floodable lengths would be somewhat reduced amidships. It is suggested that if such a form were adopted it would be greatly to the advantage of owners in shifting a vessel when light; also to builders, considering that it is necessary to have considerable stiffness when fitting out, and the ordinary ballast tanks are not always available for this purpose during construction.

THE BEHAVIOUR OF STIFFENED THIN PLATING UNDER WATER PRESSURE.*

By Professor T. B. ABELL, Member of Council.

THIS paper describes the apparatus used in experiments to determine the behaviour of a ship's plate locally reinforced by a stiffener when subjected to water pressure. It also gives the preliminary results of some experiments which were contemplated in the early summer of 1921, but which can even now only be considered very incomplete. Experimental work of the nature involved carried out amid other duties must necessarily extend over a very long period of time, measured in years. That scanty information may prove of use pending publication of the results of a more complete investigation is the justification of presentation of the results in an incomplete form. The experiments bear directly upon the suggestions put forward in a paper entitled "A Study of the Framing of a Ship,"† and were primarily conducted to establish experimentally the views put forward in that paper and expressed in the system of construction based upon that paper.

Previous Work.—The literature relating to the stresses in uniformly loaded rectangular plates is now almost extensive. The field is, however, by no means thoroughly explored, whether by the mathematician or by the experimenter, be he physicist or engineer, but our information is rapidly extending, and during the last two years there have been notable contributions in both fields—I refer to the work of Dr. Laws,‡ including his experimental investigation published by the Institution of Civil Engineers, and his mathematical discussion of the stresses in a loaded continuous beam, contributed to the *Philosophical Magazine*. The Institution of Naval Architects is fortunate in that its Transactions contain the valuable experimental researches of Dr. Montgomerie. All the literature and experiment data relate to uniform plates.

Dr. Laws has considered mathematically the problem of a "continuous" beam of "small" cross-sectional area with a sudden change in its rectangular cross-section. This does not represent the conditions existing in a plate reinforced by a narrow flexible stiffener parallel to one of the axes of the plate, but those in a plate reinforced between its supports by a doubling plate. These experiments contribute, it is believed, a first instalment on the subject, based on careful observations.

General Observations.—The test apparatus shows an endeavour to represent a panel of plating defined by two consecutive frames and, say, the centre girder and adjoining side girder of a double bottom, in so far as it is affected by normal fluid pressure only. That is to say, it is assumed free of all stresses due to loading of the structure of the ship as a whole, or stresses due to the longitudinal and transverse distribution of buoyancy and weight on the ship. The boundaries of such a panel defined by the centre lines of the rivets in each boundary will be straight under zero pressure, and will remain straight in plan when under load. Generally the material of the plate between the rivets will be subject to tension in the plane of the boundaries, whilst the rivets serve no other purpose than holding the plate in contact with the floors and girders which are assumed to be rigid.

The fixity of the plating at the boundaries is complex. Except when the pressure forces the plate away from the frames it is not symmetrical about the boundary where the attachment to the frames is by single angles. The webs of securing angles may for practical purposes be assumed to be unyielding in their plane, with the result that the heel of the angle will contribute a "point" load. The flange of the bar to which the continuous plating is attached will be flexible and will yield with the plating. The plating then is, within the ordinary application of the term, in no sense *encastré* at the boundaries. In practice, too, it is probable that the reaction from the heel of the boundary angles consists of a series of component reactions, because there will not be contact between the plate and the heel of the angle at every point along the boundary even when the pressure is against the boundary angles. The nature of the fixity is very different when the load is from within, as it would be when the tank top, unsupported by ceiling or cargo, is under pressure. The boundary will be held to the flexible flange of the boundary bars by the rivets which approximate to concentrated point loads, the rivets themselves being in tension. A detailed examination of the physical conditions existing at the boundaries of such a panel of plating in the ship convinces one that it is impossible to represent the actual conditions in a small scale test structure. Fortunately it is not necessary to do so. At the same time it is desirable to ensure that the conditions under which a test is conducted are known within small limits.

THE APPARATUS.

The Structure.—It was desirable to make the test structure on a scale which would approximate to a panel of bottom plating. The plate tested was 8 ft. by 2 ft., in the clear, and nominally 0·40 in. in thickness. It was not specially rolled, but was an ordinary good ship plate straightened to make it reasonably plane. The proportions of the plate, 4 to 1, are believed to be outside those of any previous experiments and should form a useful extension of their data.

The apparatus consisted of two such plates separated by a casting 6 in. in thickness, carefully planed on its upper and lower surfaces. Cover plates, ⅜ in. thick, were fitted around the periphery and the whole secured to the casting by two rows of bolts. Those in the outer row were ⅞ in. "through" bolts fitted to plate, cover-plate, and casting and driven home by means of a wooden mallet; the inner bolts were 1-in. tap bolts with the plain shank turned down so that they did not constrain the plate aginst end tension in its plane. The plate was thus more nearly in the condition of a plate in a ship. The edges were securely anchored by the outer bolts and gripped to the casting by the clamping effect of the inner bolts. By anchoring the plate by the outer rows of bolts the distribution of tensile stress in the portions of the plate lying between the bolts of the inner rows due to the stretching of the plate under load will approximate to that in the continuous ship's plate. This is a point which hitherto has not been sufficiently taken into account when devising experiment apparatus. The lower surface of the cover plates was planed, but the test plate was untreated in any way. To secure watertightness between the plate and the casting, a narrow strip of electrician's binding tape was worked outside the outer row of bolts. Apart from this no packing or paint whatever was used.

The details of the stiffener are indicated in Fig. 2. In order to secure satisfactory measurements of deflection the stiffeners were fitted on the inner side of the plate, leaving, except for the bolt heads, a free surface whose deflection could be measured. In the first experiment the stiffeners were hydraulically riveted to the plate, but it was found that even with the moderate ram pressure used the plating near the boundary was distorted to a degree which prevented satisfactory clamping of the plate. It was then decided to secure the stiffener by fitted bolts. These were driven in by an ordinary hand hammer, the holes being drilled and rosebitted.

The stiffeners were not bracketed at their ends, but the webs were snapped off at an angle of 30 deg. The faying surfaces of the flanges were skimmed in a milling machine so as to improve the surface of contact. No packing of any kind was used. As far as one could tell, the end of the stiffener seemed to be in contact with the plate. The stiffeners terminated ¼ in. inside the boundary of the cover plates. The tapering of the stiffener will reduce the load at its end, and if the end rivet be in tension will reduce the likelihood of its failure just as does the heel bracket. The absence of brackets certainly simplifies the difficulties of assessing the degree of fixity at the end of the stiffener.

It will be observed that, as arranged for test, the structure fails to represent a panel of tank top plating stiffened on the underside because the boundary conditions are different; it fails to represent the bottom plating because the stiffener is on the side on which the load is applied, and it fails to represent a bulkhead with water pressure on the side of the stiffener because in a bulkhead the plating is not "continuous" over its boundaries, but terminates as a rule at the boundary bar of the bulkhead. All these are very important points of detail in the ship's structure which have not been represented, but it will be found that the test will throw important

* Paper read at the Spring Meetings of the Institution of Naval Architects, March 23, 1923.
† Trans. I.N.A. (1921), vol. lxiii, page 163.
‡ *Phil. Mag., August*, 1921; Proc. Inst. C. E., 1922.

light on the action of a stiffener in conjunction with plating.

In the first test one stiffener only was fitted centrally, and may be said to represent very nearly a single stiffener parallel to the short side of a panel of infinite length. In the second test, three stiffeners were fitted, dividing the panel into four square panels. In the future it is hoped to extend these experiments by observing the effect of welding the stiffeners, instead of bolting them to the plates.

Pressure Head.—Pressure was applied by means of a standpipe into which water was pumped by a hand-pump used for boiler testing. A standpipe was used in order to retain a satisfactory constant pressure in the event of small leakage occurring. The standpipe could be readily carried to a height of 70 ft., which was enough to get deflections of sufficient magnitude to obtain reasonably accurate measurements. The pressure was measured by means of a mercury column having water and mercury in the arms of the U-tube. Pressures calculated from the indications of the mercury column were checked by actual measurements of height of water in the standpipe.

Deflections.—After the whole of the structure was assembled and bolted up, two V-shaped grooves were planed in the upper surface of one of the cover strips parallel to one of the longer edges of the panel. A heavy stiff cast-iron bridge was used as a base for measuring deflections. This was provided with three legs, two having conical ends sliding in the grooves and one a spherical end resting on the opposite cover plate. The legs were arranged so that the bridge was parallel to the short side of the panel when the conical pins were inserted in the grooves. The bridge could be placed in any position desired by sliding it in the groove, and could be located by two scales clamped, one on each side of the structure, to bolts of the upper cover plates. The upper surface of the bridge was very carefully machined; on one side was a V-groove, whilst the other was carefully milled to give a plane flat surface. A traveller carrying the micrometer gauge could be moved to any position on the bridge, and could be accurately located by an indicator placed over a scale secured to the top of the bridge. The co-ordinates of the position of the deflection indicator could then be accurately determined, and the position of the indicator could be re-set if required.

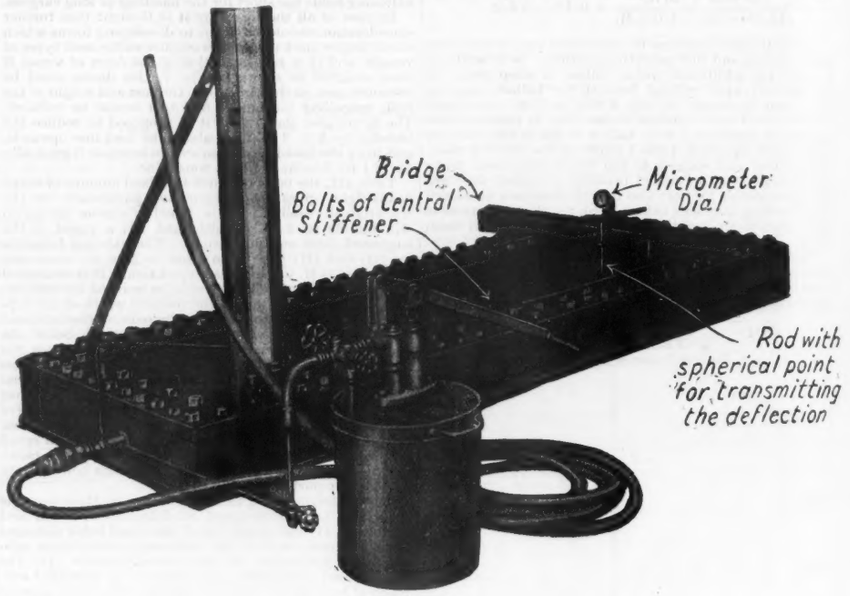
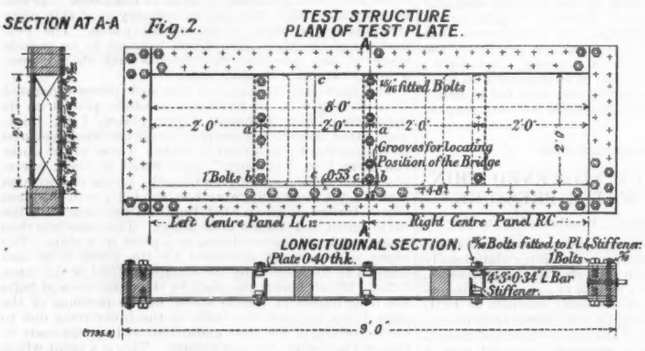


FIG. 1.



The deflection indicator consisted of a dial micrometer with a dial divided into 100 parts, each indicating 0·001 in. The pointer was fitted with a vernier which enabled readings of 0·0001 in. to be readily recorded, and by interpolation it was practicable to read to 0·000033 in. (one thirty thousandth part of an inch).

Plan of Operation.—The deflection at selected points was observed at an initial head of about 1 ft., and at intervals until 30 ft. to 35 ft. head was reached, and again at intervals with diminishing head. A check reading was taken at the initial head. The check reading determined whether any permanent set had taken place. Subsequently the test structure was subjected to 55 ft. head without the slightest sign of permanent set. With the bridge in a given position, deflections were taken at intervals sufficiently close to obtain a satisfactory curve of deflection. These intervals were $\frac{1}{16}$ in. for the first inch from the edge of the plate where the stress was likely to be a maximum. Measurements were taken of deflection of the edge of the cover plate $\frac{3}{4}$ in. in thickness. It was possible to measure these deflections and to observe that there was a greater deflection between the clamping bolts than abreast the bolts. This will be seen clearly by reference to Fig. 6, where the curve of deflection of the plate along a line $\frac{1}{2}$ in. from the edge of the cover plate is illustrated.

Method of Analysis.—Readings of the micrometers at each selected point were plotted to a base of head—actually inches of mercury. Curves were passed through the plottings and the differences corresponding to a head of 25 ft. were determined from the curve. Generally speaking, these curves were straight lines, but when the deflections were large, as they would be for points near the centre of the panels, the curves were not straight but convex to the base of pressure head.

The deflections (y) were then plotted to abscissæ parallel (z) and at right angles (x) to the long side of the plate. Curves y, to base x, and y, to base z, were obtained, bearing in mind the physical conditions existing at the edge of the plate, at the end of the stiffener, and at the heel and toe of the ends of the bar stiffener already referred to. Apart from these considerations the plottings of deflections were geometrically faired, and after faired curves had been drawn, check spots were transferred back to the original plottings to determine whether the departure from a determined deflection involved a substantial departure from the actual observations. This method of fairing is open to objection, but when using ordinary ship's plates and stiffeners, neither of which are of uniform thickness, no better method can be suggested for eliminating "erratic" determinations of deflection.

The most important points needing special attention are, of course, those at the edge of the plate and at the end of the stiffener. Mechanical difficulties prevented absolute contact being secured between the plate and the cover plate at the edge of the latter. Generally speaking, a feeler 0·0015 in. in thickness could be inserted to a distance varying from $\frac{1}{32}$ in. to $\frac{1}{16}$ in. between cover plate and the plate. This, coupled with the fact the that the deflection of the cover plate itself was measurable at the edge, and could be detected at a distance of 0·2 in. outside the edge, led to the uniform procedure being adopted of terminating the curve of y to base x, so that $y = 0$ when $x = \frac{1}{4}$ in., or $\frac{1}{2}$ in. under the cover plate.

Differentiation of the Faired Curves.—To find the stresses at any point in the plate it was necessary to determine the principal radii of curvature at the point. This involved evaluating the differentials

$$\frac{d^2y}{dx^2}, \quad \frac{d^2y}{dz^2} \text{ and } \frac{d^2y}{dx \cdot dz}.$$

Dr. Laws* had used a method of differences in his analysis, and was good enough to suggest the use of that method for the analysis of these experiments, but after consultation with Professor Proudman and Dr. Doodson it was decided to use Bessel's method of differentiation by central differences. This method seemed to give great accuracy with comparatively little arithmetic. The accuracy of differentiation by graphic methods cannot be compared with that obtained by the use of difference methods. With these methods it is necessary sometimes to exercise care in selecting the intervals at which the differences are measured, and intervals should never be so small as to make the first order of differences comparable with the errors of plotting or reading.

The method of determining the principal stresses has been previously given in the Transactions, and need not be described here.

* See Proceedings Inst.C.E., 1922.

RESULTS.

Single Central Stiffener.—The deflections of the plate in the neighbourhood of the central stiffener at the middle of the 4 to 1 panel were determined over a width of 3 in. each side of the central line of securing bolts. Observations were made at 0·5 in., 1 in., 1·5 in., 2 in., and 3 in. on each side, right ($R C_0$, $R C_{0\cdot5}$ . . .) and

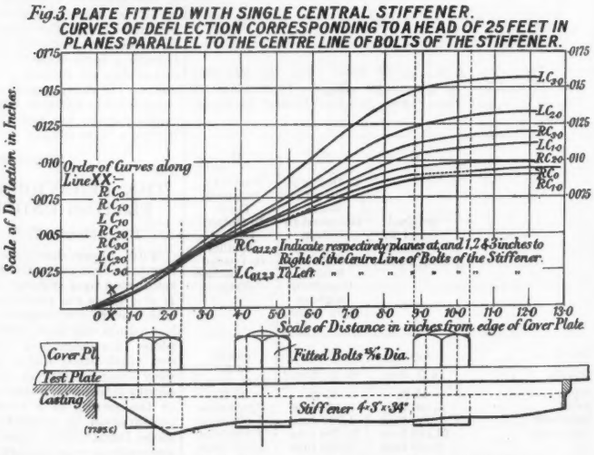


Fig.3. PLATE FITTED WITH SINGLE CENTRAL STIFFENER.
CURVES OF DEFLECTION CORRESPONDING TO A HEAD OF 25 FEET IN PLANES PARALLEL TO THE CENTRE LINE OF BOLTS OF THE STIFFENER.
Scale of Deflection in Inches.
Order of Curves along Line XX:-
RC0
RC1·0
LC1·0
RC2·0
LC2·0
RC3·0
LC3·0
RC0123 Indicate respectively planes at, and 1,2,3 inches to Right of, the Centre Line of Bolts of the Stiffener.
LC0123 To Left " " " " " "
Scale of Distance in inches from edge of Cover Plate.
Cover Pl.
Test Plate
Casting
Fitted Bolts ⅞" Dia.
Stiffener 4·5×·34"

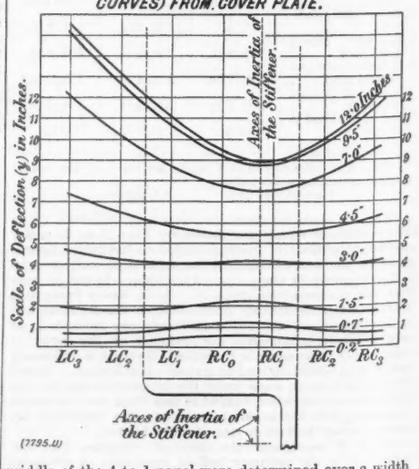


Fig.4. SINGLE CENTRAL STIFFENER.
CURVES OF DEFLECTION OF PLATE UNDER 25 FEET HEAD IN PLANES AT RIGHT ANGLES TO THE STIFFENER AT DISTANCES (STATED ON CURVES) FROM COVER PLATE.
Scale of Deflection (y) in Inches.
Axes of Inertia of the Stiffener.
13·0 Inches
9·5
7·0
4·5"
3·0"
1·5"
0·7"
0·2
LC3 LC2 LC1 RC0 RC1 RC2 RC3
Axes of Inertia of the Stiffener.

left (L C_0, L $C_{0\cdot5}$ . . .) of the centre line of the bolts, so that 11 observations were made over a width of 6 in.

The curves of deflection in planes parallel with, and at right angles to, the stiffener are shown in Figs. 3 and 4 opposite for a head of 25 ft. of water. It will be noticed that the minimum deflection at the middle of the length of the stiffener and the maximum deflection at the end of the stiffener occur almost immediately over one of the axes of inertia of the stiffener. The point of maximum deflection moves towards the toe of the bar as the depth of the web decreases. The deflections at the centre line of bolts makes an irregular curve indicating a bulging of the plate between the bolts where these bolts are in tension.

The principal stress at the end of the stiffener will be in the plane of the stiffener, whilst at the middle of the length of the stiffener it will be at right angles to the stiffener.

Fig. A, below, shows in diagrammatic form the curve of inertia of the stiffener superposed upon the inertia of the plate, assuming each to act independently of the

DIAGRAM SHOWING VARIATION OF CROSS SECTIONAL INERTIA OF STIFFENER AND PLATE SUPERPOSED NOT COMBINED.

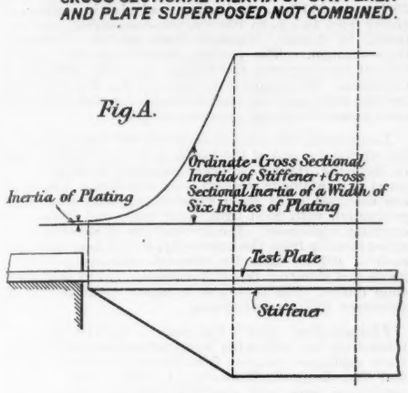


Fig.A.
Ordinate = Cross Sectional Inertia of Stiffener + Cross Sectional Inertia of a Width of Six Inches of Plating
Inertia of Plating
Test Plate
Stiffener

Fig.5. SINGLE CENTRAL STIFFENER. CURVE OF DEFLECTION OF THE PLATE UNDER 25 FEET HEAD IN THE MAJOR-AXIAL PLANE a a.

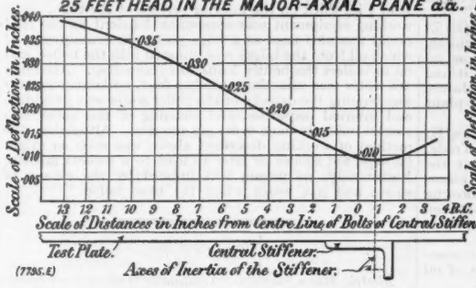

Scale of Deflection in Inches
Scale of Distances in Inches from Centre Line of Bolts of Central Stiffener.
Test Plate.
Central Stiffener.
Axes of Inertia of the Stiffener.
(7735.E)

Fig.6. SINGLE CENTRAL STIFFENER. CURVE OF DEFLECTION OF PLATE UNDER 25 FEET HEAD IN A PLANE DISTANT 16" FROM THE C.L. OF BOLTS OF THE STIFFENER.

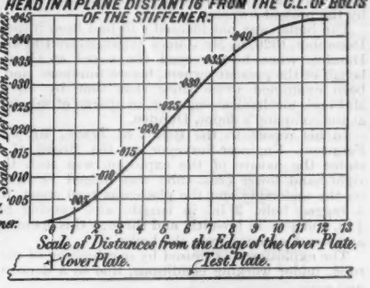


Fig.7. PLATE FITTED WITH THREE STIFFENERS. CURVES OF DEFLECTION OF PLATE UNDER 47 FEET HEAD IN PLANES a a & b b.

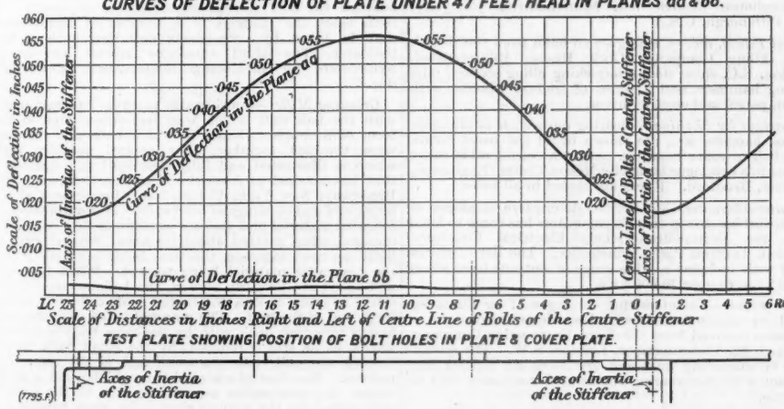
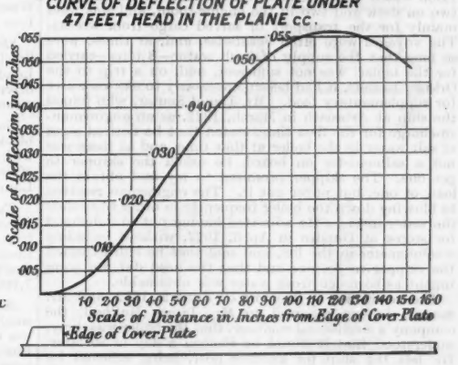

Scale of Deflection in Inches
Axis of Inertia of the Stiffener
Curve of Deflection in the Plane a a
Curve of Deflection in the Plane b b
Centre Line of Bolts of Central Stiffener
Axis of Inertia of the Central Stiffener
Scale of Distances in Inches Right and Left of Centre Line of Bolts of the Centre Stiffener
TEST PLATE SHOWING POSITION OF BOLT HOLES IN PLATE & COVER PLATE.
Axes of Inertia of the Stiffener
Axes of Inertia of the Stiffener
(7795.F)

Fig.8. PLATE FITTED WITH THREE STIFFENERS. CURVE OF DEFLECTION OF PLATE UNDER 47 FEET HEAD IN THE PLANE c c.



other. By tapering the web of the stiffener the marked discontinuity in inertia of cross-section lies at the point where the taper from the full length of the flanges commences. At the end of the bar the inertia is comparatively small, with the result that the force delivered to the plate by the bar at its end, or by the last rivet or bolt, depending upon the side from which the pressure is applied, will be comparatively small. The practical result is that a very large proportion of the total available strength of the stiffener can be utilised without a marked concentration of load at the end of the stiffener, without the usual expedient of a bracket, and without unduly stressing the end rivets.

Designers would be glad of some empirical rule for assessing the width of plating which, taken together with the stiffener, would form an equivalent beam to the actual plate and stiffener. Various suggestions for the width of plating in terms of its thickness have been made. A glance at the curves of deflection will not help the designer beyond illustrating the way in which the stiffener is loaded when the water pressure is tending to separate the plate from the stiffener. The stiffener does not appear to derive much assistance from the plating. The determination of the stresses in the plating in the line of rivets and in the flange of the stiffener will be most difficult, because between the rivets the plating will be forced away from the stiffener, and, whilst it might be possible to survey the surface of the plate, it is impossible to survey the flange of the stiffener. Here, as so often in experiments on a practical scale, so many factors which cannot be entirely taken account of enter into the problem that eventually one must fall back on rough determinations, such as the load which will just give permanent set. The actual test structure with three stiffeners has been submitted to a pressure head of 55 ft., which would give a stress of 16 tons per square inch, if the plating were unstiffened, without the slightest indication of permanent set.

A careful analysis of the observations made under a head of 25 ft. yields some valuable information bearing on the behaviour of stiffened plates. The maximum stress in the plate with the single central stiffener at the edge of the cover plate is estimated to be 4½ tons per square inch, decreasing markedly on either side of the plane of maximum stress. For the unstiffened plate a panel of the same width and infinite length the stress would be 8¾ tons per square inch, which reduces to 7½ tons per square inch if the length of the panel is four times the breadth. The fitting of this tapered stiffener reduces the stress at the middle point of the long side then by 2¼ tons per square inch, or by 38 per cent. If the central stiffener had provided a rigid boundary, the maximum stress at the middle of the long side of each panel so formed would be about 4·83 tons per square inch. With the tapered stiffener of the experiments, therefore, the maximum stress at the middle of the long side is not greater than it would be if the panel had been unstiffened, and the proportions had been 2 to 1 instead of 4 to 1. The result would have been very different and the stress higher if the stiffener had been kept of the same cross-sectional area throughout. The comparatively recent practice of spacing the rivets more closely at the end of stiffeners accords with the result of this test. But it is

panel between the centre and the adjacent stiffeners is almost exactly the sum of the deflections of the stiffeners, and the deflection of the panel had the stiffeners been rigid. This may give rise to a useful method of estimating the spacing of stiffeners required in any particular distribution of stiffeners. The deflection of the side stiffener is only slightly less than that of the central stiffener.

The curve *b b* shows very clearly the effect of the clamping of the plate by the cover plate, there being maximum ordinates at positions between the bolts, and minimum ordinates abreast the bolts. It is hoped at another time to supplement these particulars by further experiments, including some on welded stiffeners. It will then be practicable to form more definite comparisons between the part played by a stiffener which is riveted to the plate, and by a stiffener welded to the plate.

The experiments are sufficient to show that there are still great possibilities of effecting simpler and less expensive connections of many parts of the ship's structure by careful attention to details. That has been the aim of Mr. Gebbie and the author in working out the details for the application of the principles underlying these experiments to the construction of various parts of the ship's structure, particularly of the double bottom. The application has received the approval of Lloyd's Register of Shipping and the British Corporation for the Survey and Classification of Shipping. These experiments substantiate the proposition that free-ended stiffeners suitably designed can be used to reinforce a thin plate in a manner which will avoid concentration of stress and effect a substantial general reduction of stress throughout the boundaries of the plate.

thought that these experiments indicate that, in certain cases, *e.g.*, where the plating subject to normal pressure is continuous over supports, and does not terminate at the support as in bulkheads, it is practicable, and it would be certainly economical, to dispense with end lugs or bracket attachments if care were taken to relieve the stress on the end rivets by closer spacing, which is expensive, or by snapping the stiffener, which is cheap. Complete calculations for the determination of the stress at other parts of the plate have not yet been made. Stresses will reach maximum values at the boundaries at points midway between the stiffeners, and at the middle of length of the stiffeners. At the latter positions the stresses will probably reach their maximum values because of the nature of the load on the plate. Here the direction of the maximum stress will be at right angles to, and not in the plane of, the stiffener.

A portion of the curve of deflection in the major axial plane of the plate, corresponding to a head of 25 ft., is shown in Fig. 5. Unfortunately this curve was not completely determined for the whole panel before the additional stiffeners were fitted, because it was thought at the time that for practical application of the results it would be sufficient to determine deflections in the neighbourhood of the stiffener only. Fig. 6 shows the curve of deflection, corresponding to a head of 25 ft., in a plane 16 in. from the centre line of bolts of the stiffener.

Three Stiffeners.—The presence of the webs of the casting restricted the spacing of the additional stiffeners to 2 ft., thus giving four panels, square in outline. The surface of this plate under load has not been completely surveyed; curves of deflection under a head of 47 ft. of water are shown n Fig. 7 for the planes *a a*, *b b*, *d d* (see Fig. 2), and in Fig. 8 for the plane *c c*.

One or two interesting features are revealed by these curves. The maximum deflection at the centre of the

WASTE HEAT FROM COPPER-REFINING FURNACES.—The utilisation of the waste heat of metallurgical furnaces is often neglected because of the complications of the plant. According to C. Gaab (*Zeitschrift des Vereines Deutscher Ingenieure*), two waste heat plants, installed in connection with copper refining furnaces of the Grusonwerk type have given complete satisfaction. The furnaces of a battery are run so that operations are continuous, one furnace of a pair being at high heat, while the other is being recharged, so that the total waste heat available is practically constant throughout the 24 hours' day. The first plant installed in 1916 consisted of boiler, superheater, fuel gas preheater and draught machinery: a similar, larger installation followed in 1917, and both these installations are still in service. From the statistics of last year it would appear that about 1,100 kg. (from 930 to 1,200) of steam were generated per hour at 280 deg. C. (536 deg. F.) and a pressure of 13 atmospheres (185 lb. per square inch) from water at about 64 deg. F., when the furnaces consumed from 190 kg. to 200 kg. of coal per hour to melt 750 kg. to 835 kg. of copper per hour. The weight of copper dealt with was actually increased (the former weight had been 625 kg. per hour), and there was no trouble with smoke; both these improvements were ascribed to the adoption of artificial draught in the furnaces. A considerable saving of the fuel required for heat and power is claimed.

BOILER EXPLOSION ON BOARD A STEAMSHIP.

A PRELIMINARY inquiry has been made by the Board of Trade, under the provisions of the Boiler Explosions Acts, 1882 and 1890, with regard to the cause and circumstances attending the explosion of a boiler which occurred on June 8 last, on board the S.S. Ixion, whilst the vessel was on a voyage from Bridgeness to Stromness. Fortunately, no one was injured by the explosion.

The vessel was owned by the East Coast Salvage Company, Limited, 39, Dock-street, Dundee.

The boiler from which the explosion occurred, was of the vertical, cross-tube type, 15 ft. in height, and 6 ft. 3 in. in diameter, made of steel, and worked at a pressure of 95 lb. per square inch. The fire-box, which was 5 ft. in diameter, had four horizontal steel cross-tubes, 12 in. in diameter, and ⅞ in. in thickness. There were six hand holes, for cleaning purposes, 8 in. by 5 in.; four were opposite the cross-tubes and two were at the bottom of the water space and close to the fire door. The usual boiler mountings were fitted.

The boiler was not new when fitted on board the Ixion in 1915, and the name of the maker and the age of the boiler could not be ascertained.

The fire-box, uptake and cross-tubes were renewed in 1915, previous to placing the boiler in the ship. It was not possible to obtain particulars of repairs done, if any, between 1915 and 1920, whilst the vessel was on Government service, but no repairs had been done to the boiler by the present owners.

The boiler was not insured and had been inspected in December, 1920, by Mr. James Fettes, consulting engineer, Dundee, when he surveyed the vessel at Glasgow on behalf of the present owners, before purchase, and it had been examined twice since that time by Mr. James McPhail, mechanical engineer, in charge of salvage plant at the company's depot, Dundee.

In his report to the Board of Trade, Mr. John H. Ferguson, Engineer-Surveyor to the Board of Trade, states the nature of the explosion was such that the right-hand lower cross-tube was bulged in two places on the underside and the plate was torn apart, forming a ragged hole, 3 in. in length, and varying between ½ in. and ¼ in. in breadth, and through this opening water and steam escaped from the boiler.

The explosion was caused by overheating of the cross-tube, under working conditions, due to a deposit of oil and scale.

Mr. Ferguson states in his "General Remarks," the Ixion was a small steamer with a crew of four persons, two on deck and two in the engine-room, and was used mainly for the transport of salved cargo from wrecks. The voyages were often coastwise, and, at times, were so long that the supply of fresh water—8 tons—carried for the boiler, was not sufficient, and, on a trip to the Orkney Islands, it had become necessary to use sea water for supplementary feed. Mr. David Soutar, who joined the ship at Arbroath in March, 1922, as an engineman-in-charge for the first time, stated that he noticed signs of salt water in the boiler at that time, and as there was not a salinometer on board, he asked the skipper to get one. The skipper promised to try and obtain the loan of one, but never got it. The engineman resorted to blowing down the boiler frequently in order to freshen the water inside. He admitted having put in a demand for stores at Dundee in April, 1922, without including a salinometer in the list, and said that he still expected the skipper to get one and that the need did not seem urgent as so much fresh water was obtainable.

The vessel was in Tayport on June 2, 1922, and Mr. Soutar, having reported to Mr. James McPhail, the company's mechanical engineer, that the boiler was dirty, understood that it would be cleaned a day or so later. He left the ship for another post, being relieved by Mr. John Sutherland, who had been engineman in the ship previously from February, 1921, to the end of that year.

Mr. Sutherland stated that when he rejoined the Ixion he noticed there was a lot of fuel oil in the bilges, and he tried the density of the water in the boiler with a salinometer, which was his own property, and found it to be fully $\frac{5}{32}$. This was reduced to $\frac{1}{32}$, during the next two days, by blowing down.

Four days later, while on a voyage to the Orkney Islands, the explosion occurred. The fireman, Mr. Sydney Park, was on watch at 3.30 a.m., and had raked the fire and gone on deck for a few minutes. He was just starting to descend the engine-room ladder when there was a rush of steam from the boiler furnace. He called Mr. Sutherland, but it was a quarter of an hour before they were able to go below. The engines were still running, and about 80 lb. pressure was showing on the gauge. The boiler fire was found to be extinguished, and it was seen that the right-hand lower cross-tube had failed, as previously described. The Ixion was towed to Fraserburgh, where the tube was patched and she then proceeded to Stromness and returned to Dundee, where the tube was taken out of the boiler. The tube was found to be bagged about ½ in., as might have been expected from the working conditions.

The supervision of the care and maintenance of the boiler was left to Mr. James McPhail, who had had twelve months' experience at sea. He arranged to examine the boiler twice a year at convenient times; and it was emptied and cleaned for his examination in April, 1921, and in January, 1922. He had intended to examine it next when the vessel came back from Stromness in June, 1922; and it appeared that these examinations were the only times when the boiler was opened and cleaned. Mr. McPhail stated that at each examination the condition of the boiler was satisfactory, and that the amount of scale to be removed was small. He further stated that he did not know that the engineman, Mr. Soutar, had not been in charge of engines and boilers before, and understood that he had been recommended to the skipper at Arbroath as having been an engineman in fishing craft. He did not think it necessary, therefore, to exercise extra supervision in his case.

When the boiler was opened out at Fraserburgh on June 9, 1922, the damaged tube was found to have a deposit of scale, about ¾ in. in thickness, firmly attached to the lower part. There was a considerable amount of black grease in this scale and free oil was also present in other parts of the boiler. Mr. Ferguson reports that he had seen the damaged part, which was cut out from the tube at Fraserburgh, and there was scale and oil still adhering except at the point of failure where there was a clear indication of overheating.

Concluding his report, Mr. Ferguson states that there was no doubt that, although both the enginemen stated that they took great care to wash through the donkey pump after using it on the bilges, the boiler must have been fed frequently with water which was contaminated with oil. Moreover, the period which was allowed to elapse between each cleaning was too long for a boiler of this description, and it did not seem to have occurred to anyone concerned that there was a danger from oil finding its way into the boiler. It is very undesirable for a pump with a bilge connection to be used for feeding a boiler, as it was in this case.

In reviewing the report, Mr. Thomas Carlton, Engineer Surveyor-in-Chief to the Board of Trade, in his "Observations" states: "The failure of this tube was apparently due to a heavy deposit of lime scale, this being no less than ¾ in. thick on the interior surface of the tube. The working equipment was somewhat deficient as the feed pump was also used as a bilge pump, in consequence of which oil from the bilges was pumped into the boiler, and oil in boilers frequently leads to overheating. Although sea water was sometimes used as feed, no instrument for ascertaining the density of the boiler water was provided, and internal inspection and cleaning of the boiler was carried out only once every six months. Altogether, the method of working described above was such as might be expected sooner or later to lead to a serious mishap. Fortunately, no person was injured by the escape of steam and hot water when the tube failed."

CATALOGUES.

Electric Motor Starters.—Automatic starters for wound-rotor induction motors, ranging from 5 h.p. to 1,000 h.p., are the subject of a special catalogue received from the Westinghouse Electric and Manufacturing Company, East Pittsburgh, U.S.A.

Steel Piling, &c.—Catalogues to hand from the British Steel Piling Company, Dock House, Billiter-street, London, E.C. show steel interlocking piling section, pile-driving hammers and a series of friction winches with steam, petrol and electric drives.

Bearings for Shafting.—Bearing units such as plummer blocks, hangers, &c., are shown in all the usual forms, with ball or roller bearings, and in a considerable range of sizes in a catalogue issued by Messrs. Crofts (Engineers), Limited, Bradford. Prices are stated in all cases.

Turbo-Alternators.—A further descriptive catalogue of steam-turbine driven electric generators has come to hand from the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester. The list of plants dealt with includes a wide range of outputs from about 1,100 kv.a. to over 30,000 kv.a.

Air Filter.—An interesting catalogue of air filters for small air compressors, air brakes, electric motors, &c., has been received from the Visco Engineering Company, Limited, 82, Victoria-street, London, S.W. The advantage of extracting dust and grit from air coming into contact with the wearing surfaces of machinery will be obvious.

Foundry Moulding Machines.—A catalogue of moulding machines and hand tools made by the Bonvillain and Ronceray Company, Paris, and issued by the Universal System of Machine Moulding and Machinery Company, Limited, 97, Queen Victoria-street, London, E.C., shows a great variety of equipment of considerable interest to foundrymen.

Electric Motors.—Large polyphase induction motors, of open type with pedestal bearings, and with outputs of 100 b.h.p. to 1,100 b.h.p., are described in a special catalogue issued by Messrs. Crompton and Co., Limited, Chelmsford. Tables giving the brake horse-power, speed, slip, efficiency and power factor at different loads for each machine are included.

Transformers.—An illustrated description of their transformers, including special types for use with rotary converters, for colliery work, and for supplying electric furnaces, &c., is to hand from the Brush Electrical Engineering Company, Limited, Loughborough. The text and illustrations convey the necessary information in a very effective manner.

Electric Drive for Rolling Mills.—Full particulars of electric drives for both reversing and continuous rolling mills are given in a list of equipments made by the English Electric Company, Limited, Queen's House, Kingsway, London, W.C. The list occupies 8 quarto pages, and its object is to show the variety of conditions which the company has successfully dealt with.

Steel Beams.—A handbook of technical information on steel beams, girders, stanchions, &c., has been issued by Messrs. R. A. Skelton and Co., Steel and Engineering, Limited, Moorgate Station Chambers, London, E.C., in connection with their broad-flange beams (Grey process). The information, which is exceptionally complete, occupies 190 pages, and the price of the handbook is 5*s.* net.

Laundry Ironing Machine.—Particulars of their improved Decondun ironing machine are to hand in a special catalogue issued by Messrs. Manlove, Alliott and Co., Limited, Nottingham. The machine comprises a steam-heated half-circular bed with polished surface in which a blanket-covered roller revolves. It is used for drying and smoothing linen, and is well equipped with every convenience for operation, and carefully guarded to prevent accidents to the workers.

Aluminium.—A compact and clearly-printed pocket book containing a most comprehensive collection of facts and figures relating to aluminium has come to hand from the British Aluminium Company, Limited, 109, Queen Victoria-street, London, E.C. The information covers the physical properties, methods of working, sizes and weights of manufactured sheets, sections, wires, tubes of aluminium and other materials, and also includes particulars of finished parts for electrical wiring.

Steam Engines.—A new catalogue of semi-portable steam engines made in eight sizes, developing from 50 h.p. to 250 h.p. condensing, and also in eight sizes giving from 38 h.p. to 190 h.p. non-condensing, has been issued by Messrs. Marshall, Sons and Co., Limited, Gainsborough. The powers above-mentioned are for normal working, and the engines can deal with heavy overloads. The engine is mounted on top of a horizontal firetube boiler and the type is notable for high efficiency, good accessibility, and economy in space.

Locomotives.—A handsome series of illustrations of the workshops and of the locomotives produced in them by Messrs. J. Hanrez, Monceau-sur-Sambre, Belgium, are given in a catalogue received from that firm. The shops are designed on a scale suitable for large and rapid production with good light, floor space and lifting and carrying appliances. The locomotives illustrated are a series ranging from the express type with four cylinders, each of 19¾ in. diameter, through ordinary passenger, goods and shunting types to engines for yard and work-shop duties. The catalogue is highly creditable to all concerned with its production.

Thermometers and Pyrometers.—Instruments for measuring and indicating temperature are explained in three catalogues received from Messrs. Siemens Brothers and Co., Limited, Woolwich, London. One of these catalogues deals with electrical distance thermometers for a temperature range from — 200 deg. to 500 deg. C., and another with the same type of thermometers specially adapted for cold storage chambers on shipboard. In both cases the readings of a number of instruments may be taken by successively switching each to one indicator. The third catalogue relates to optical pyrometers for measuring temperatures above 600 deg. C.

Grinding Mills.—Considerable progress has been made with the ball mill, which was first constructed in the form of a simple cylinder in which balls and material were tumbled together. The conical tumbler mill, which is illustrated and fully described in a catalogue that has reached us from the Hardinge Company, 120, Broadway, New York, U.S.A., has a bottle-neck at the larger end and openings at both ends. It is automatically fed with material and yields a continuous flow of ground material when rotated about its axis. Several sizes of balls are used together, the sizes being selected to suit the particular material being treated. When the balls and speed are properly chosen, the balls arrange themselves in order of size, the largest balls collecting at the large end of the mill. The material is fed in at this end and is thus first dealt with by the large balls and afterwards, as its size is reduced, by the small balls, finally leaving the mill from the small end in the form of a powder. The flow of material through the mill and the degree of pulverisation are entirely due to the natural path taken by the various-sized balls when tumbled in the conical container; the axis of the container is horizontal and there are no mechanical distributors. The mills are suitable for either wet or dry grinding. The catalogue illustrates several installations, one of which includes 64 mills, each 8 ft. in diameter.

MINERALS IN WESTERN AUSTRALIA.—The report for the Department of Mines of Western Australia just received shows that in 1921 the gold output of the State further declined, and the total value of minerals produced, amounting to 2,880,169*l.*, was 379,242*l.* less than in the year 1920. The only mineral showing an appreciable increase was coal; this, however, only amounted to an improvement of 6,796 tons on 468,817 tons. The coal was all produced from the Collie district. This district produces qualities of coal with an ash content ranging from 4 per cent. to 8 per cent. and a calorific value as received of about 9,000 B.Th.U., or 12,000 B.Th.U., moisture free. The volatiles range from about 25 per cent. to 32 per cent. State boring conducted in the Wilga district about 25 miles south of Collie indicate the presence of coal there of a somewhat similar character, not yet commercially developed, though proved to exist in seams ranging up to 9 ft. thick. The majority of the seams are, however, thin and of from 1 ft. to 3 ft. thickness only. Boring has also been conducted on the Irwin River, south-east of Geraldton, where numerous thin seams have been located. Two thicker seams have also been struck, viz., one of 4 ft. 2 in. at a depth of 451 ft., and one of 12 ft. at 525 ft. These coals are, however, unfortunately very high in ash content and moisture, and have a calorific value of only between 5,700 B.Th.U. and 6,880 B.Th.U.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

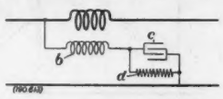
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

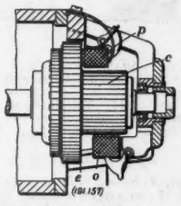
ELECTRICAL APPARATUS.

190,613. Chamberlain and Hookham, Limited, Birmingham, and S. James, Birmingham. Measuring Alternating Currents. (2 *Figs.*) November 21, 1921.—The invention relates to instruments of the induction meter type for measuring or indicating the wattless component of alternating currents,



The invention comprises the use of a condenser *c* in series with the voltage coil *b*, so that the flux due to that coil is in phase with the applied voltage. Also the invention comprises the use of a resistance or inductance *d* in parallel with the condenser. (Sealed.)

191,157. E. C. Hatcher, Finchley, London. Dynamo-Electric Machines. (4 *Figs.*) October 6, 1921.—The invention relates to commutators for dynamo-electric machines of the kind wherein separate sets of commutator segments insulated from each other so as to form separate brush contact surfaces are provided, each set of commutator segments being connected to corresponding separate sets of windings on the armature. According to the invention, in a double commutator device of the kind referred to, the conducting segments *e* of one set are arranged to provide a substantially cylindrical brush contact surface and the



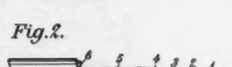
conductor segments *e* of the other set are arranged to form a substantially disc-like brush contact surface. The cylindrical surface instead of being truly cylindrical, may be tapered or conical, and the disc-like surface instead of being flat and perpendicular to the commutator axis may be inclined thereto so as to be likewise conical. With this arrangement of the commutator segments, two pairs of brushes *o*, *p* are provided, one pair for each set of segments, or one pair of brushes may be provided having contact faces spaced apart to make contact only with the corresponding commutator segments. (*Accepted January* 17, 1923.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

191,151. H. W. Sullivan, London. Submarine Telegraph Cables. (2 *Figs.*) October 5, 1921.—The invention relates to submarine telegraph cables, its object being to provide an improved construction of cable which shall either have a lower K R value for a given cost or a lower cost for a given K R value as compared with cables as now constructed. According to the invention,

Fig.1.

Fig.2.



there is provided an electric signalling cable in which the covering comprises, in combination, a sleeve 6 of gutta percha surrounding the signalling conductor 1, a sleeve 4 of impregnated paper enclosed by the gutta percha sleeve 6, and a layer 3 of magnetic metal within the sleeve of gutta percha and insulated from the signalling conductor by gutta percha 2. (*Accepted January* 17, 1923.)

190,756. J. T. Booth, Handsworth, Birmingham. Internal-Combustion Engines. (11 *Figs.*) August 27, 1921.—The invention relates to two-stroke internal-combustion engines. In an internal-combustion engine having a reciprocating valve for controlling the passage of gas to a pumping device and from the pumping device to a receiver and a reciprocating valve for controlling the passage from the receiver to the working cylinder or cylinders, two cylindrical through-ported valves are provided, according to the present invention, one of which controls the passage of the gas to the pumping device and from the latter to the receiver, and the other of which controls the passage of the gas from the receiver to the working cylinder or cylinders. The receiving chamber 1 and the transfer valve 2 are located between the two working cylinders 3, the axis of the receiving chamber 1 being at right angles to the axes of the cylinders whilst the transfer valve consists of a sleeve working in the cylinder 4 arranged between the upper parts of the two working cylinders upon an axis which is at right angles thereto. The inlet valve 5 comprises a ported cylindrical valve working in a cylinder 6 arranged in front or to the rear of the working cylinders and upon an axis parallel thereto. The shaft 7, from which the valves 2, 5 are operated, is arranged at a point where the axes of the inlet and transfer valves intersect. The shaft 7 is driven from the main shaft 8 of the engine. The pump cylinders 9 are arranged beneath the working cylinders 3, the working pistons being provided with an enlarged portion for operating in the pump cylinders in the known way. Passages 10 lead from the cylinder 6 to the pump cylinder 9. The inlet valve 5 is provided with two ports 11, 12, one of which serves to place the induction pipe 13 in communication with one pump cylinder 9, and the other of which serves to place the induction pipe into communication with the other pump cylinder. The inlet valve is hollow and the ports 11, 12 pass across the valve and are isolated from its interior (see Figs. 2 and 3). The inlet valve is also provided with ports

Fig.1.

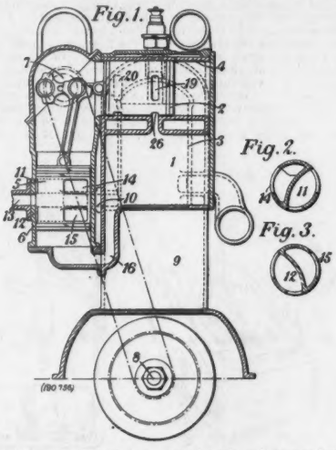
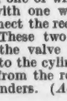


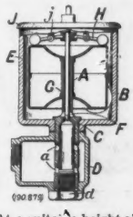
Fig.2.

Fig.3.



14, 15, which are adapted to receive the gas as it passes from the pump associated with one working cylinder through the hollow interior of the inlet valve and passage 16 to the receiving chamber 1. The lower end of the inlet valve is open and the upper end is closed. The transfer valve 2 consists of a sleeve working in a cylinder 4 and having two ports, one of which 19 serves to connect the receiving chamber 1 with one working cylinder and the other of which 20 serves to connect the receiving chamber with the other working cylinder. These two ports 19, 20 are spaced apart along the length of the valve 2. A port 26 is provided leading from the receiver into the cylinder 4, which port allows of the passages of the gas from the receiver through the ports 19 or 20 into the working cylinders. (*Accepted January* 10, 1923.)

190,879. P. A. Poppe, Coventry. Carburettors. (1 *Fig.*) November 22, 1921.—The invention relates to an improved float feed mechanism for carburettors. Mounted in the bottom of the float chamber B is a guide tube A having an upper part projecting into the chamber B and a lower part which extends beyond the bottom of chamber B. The lower part is provided with a seating C for a needle valve G which is guided in the upper



part of the tube A. At a suitable height above the seating C fuel outlets F are provided in the tube A. A float E is fitted with a suitable clearance around the guide tube A and float levers H are pivoted to projections *j* carried by the lid J of the float chamber. The lower end of the guide tube A is provided with fuel inlets *a* which communicate with a fuel supply pipe connection or filter chamber D, which surrounds the said lower end and is held in position by a bolt *d* which screws into the said tube. (*Sealed.*)

HYDRAULIC MACHINERY.

191,197. Whitehall Petroleum Corporation, Limited, Westminster, and J. B. Munn, West Ealing. Gate Valves.

Fig.1.

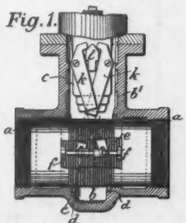


Fig.2.

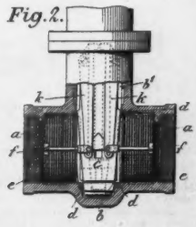
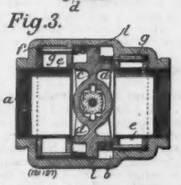


Fig.3.



(4 *Figs.*) October 18, 1921.—The invention has reference to gate valves of the kind having a sleeve located in the body of the valve casing and adapted, when the valve is open, to form a continuous tube-like passage through the chamber of the casing between the inlet and outlet branches, so that the fluid is prevented from coming in contact with the bearing faces of the valve discs and seats. According to the invention, in a gate valve of this kind having opposed passageways *a*, *a*, a sleeve *e* slides into and out of each passageway across the intervening chamber *b*, which the valve *c* enters transversely to close the passageways *a*, *a*, and the sleeves *e* are adapted to be actuated positively in each direction by the opening and closing movements of the valve *c* through the medium of lever mechanism. The valve *c*, when closed (Fig. 2), makes a tight joint with seatings *d* around the branch passages *a* and, when open (Fig. 1), occupies the lateral extension b^1 of the chamber *b* as well understood. The remote end of each sleeve *e* has a lug or projection *f* which occupies a recess *g* in the casing, and has projecting from it a rod that passes into the chamber *b*, where each rod is coupled to a lever *k* fulcrummed in the extension b^1 of the chamber *b*. The valve *c* is formed with a pair of camlike projections *l*, which extend between the levers *k* and the levers are so bent that when the valve *c* is open, they cross each other towards their connections with the sleeves *e* and the projections *l* lie between their opposite end portions beyond the lever fulcrums and hold the levers in such a position that the sleeves meet and bridge the gap between the valve seatings *d* as shown in Fig. 1. At the commencement of the closing movement of the valve, the projections *l* move to the other side of the lever fulcrums and spread open the crossed levers *k*, thus sliding the sleeves back into the passages *a* clear of the closing valve. (*Accepted January* 17, 1923.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

190,888. Belliss and Morcom, Limited, Birmingham, and A. C. Pain, Edgbaston, Birmingham. Air Compressors. (4 *Figs.*) December 3, 1921.—The invention relates to multi-stage high pressure reciprocating air compressors of the type in which the several stages of compression are effected in a pair of lines of tandem cylinders. According to the invention, an odd number of compression stages is employed alternating between each line of cylinders, but with one of the intermediate stages divided between both lines of cylinders, the result being that although an odd number of stages is employed, the number of cylinders is even. The multi-stage high-pressure reciprocating air compressor illustrated has two lines of tandem cylinders A and B, the pistons of which are reciprocated by cranks set 180 deg. apart and driven by a suitable motor. Five compression stages are provided. Referring more particularly to Figs. 3 and 4, compression stage one is effected in the bottom

Fig.1.

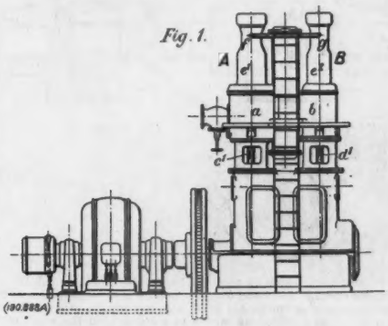


Fig.3.

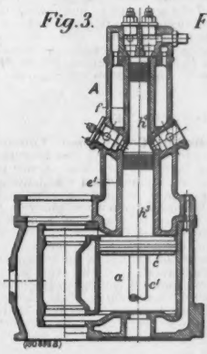
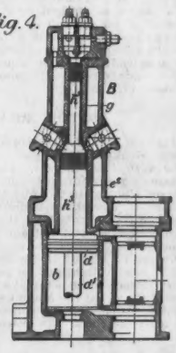


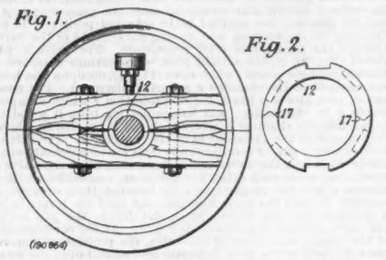
Fig.4.



cylinder *a* of the vertical line of superposed tandem cylinders A. Stage two is effected in the bottom cylinder *b* of the other line of cylinders B. These two cylinders *a*, *b* are double-acting, and their pistons *c*, *d* are, as stated, driven by cranks set 180 deg. apart. The third stage is a divided stage, and is effected in parallel in a cylinder c^1 in one line directly above the first stage cylinder *a*, and in a cylinder c^2 in the other line directly above the second stage cylinder *b*. The discharge from the two third stage cylinders c^1, c^2 is then subjected to the fourth stage of compression in a cylinder *f* above the third stage cylinder c^1, whilst the fifth and final stage is effected in the top cylinder *g* of the line of the second stage cylinder *b*. The plungers h^3, h^4, h^5, of stages three to five are single-acting, and are constituted by trunks, shouldered to the respective diameters, in prolongation of the respective piston rods c^1, d^1, of the two pistons *c*, *d* of the two lines of cylinders A, B. (*Sealed.*)

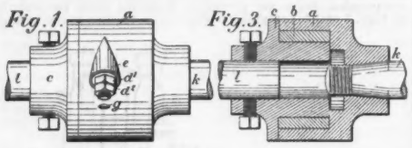
190,864. H. P. Harris, London, and Metal and Hardware Products, Limited, London. Bearing Bushes or Brasses. (4 *Figs.*) November 14, 1921.—The invention relates to bearing bushes or brasses of the two-part type having the parts abutting along surfaces lying longitudinally to the axis of the shaft of the bearing on opposite sides thereof, the abutting surfaces being of shaped formation to lock the two bush parts together against relative movement along the surfaces in the direction radial to the axis. According to the primary feature of the invention, bearing bushes or brasses of the type described are provided which are characterised by the fact that the two bush parts 12 in a pair are made each, throughout its length along the axis of the bearing, of the same shape in cross-section in all planes at right angles to the said axis, and are of similar formation one to the other with

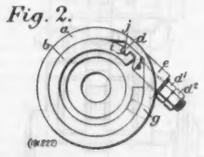
the shaped abutting surfaces 17 on one side of the axis reversed relatively to those on the other side of the axis, so that the bush parts can each be formed by extrusion through the same die aperture which has the shape of half an annulus. Thus a length



of the required shape can be extruded through the die and subsequently cut into pieces of suitable dimensions each to form the half of a bush, and since the faces which are to abut against each other are reversed on the one side as compared with the other, the two halves will fit together. (*Sealed.*)

191,222. B. C. Bestwick, Totley, and H. Woodworth, Dore. Friction Couplings or Clutches. (8 *Figs.*) November 8, 1921.—The invention relates to adjustable friction couplings or clutches. In carrying out the invention as applied to a magneto coupling for example, the outer case is cupped or recessed to receive a flanged friction drum. The friction drum is of less diameter than the interior of the casing, and within the space between the two and encircling the friction drum is a spring steel friction band or strap which is secured at one end to the inner face of the casing, its other or free end being attached to a screw-threaded bolt which passes through a hole or slot in the case and is secured in position by a nut. *a* is the outer case of

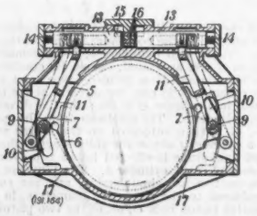




the coupling, which is recessed to receive the flanged friction drum *c* and friction band *b*. The band *b* is secured at one end to the inner face of the casing by a grub screw *g*, its other end being connected to a bolt *d* by means of a recess *i* on the band and a lug *j* on the bolt *d*, the lug fitting into the recess as shown in Fig. 2. The frictional grip between the outer case and the drum is adjusted as desired by slightly screwing or unscrewing the nuts *d*1, *d*2 on the bolt *d*. A projection *e* may be formed upon the casing *a* for the nuts *d*1, *d*2 to bear against. The magneto armature shaft *k* is secured in the casing by means of a nut screwed upon its end. This nut is not shown in the drawings, but the recess made to receive it is shown. *l* is the camshaft. (*Accepted January* 17, 1923.)

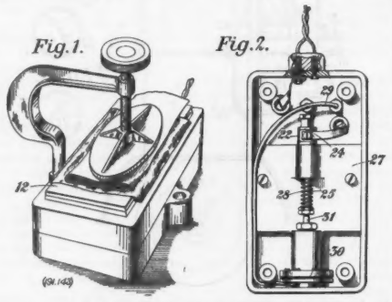
MOTOR ROAD VEHICLES.

191,164. E. J. De Normanville, Cricklewood, London. Band Brakes. (3 *Figs.*) October 7, 1921.—The invention relates to band brakes. This invention provides means for braking a rotary drum 5 comprising a brake band 6 and spring-pressed plungers 13 to which the ends of the band are respectively connected, directly or indirectly, so that when the plungers 13 are free to be moved by the springs 14, the brake band 6 is tightened upon and restrains rotation of the drum 5. The invention also comprises means for moving and holding the plungers 13 against the action of the springs 14 to release the brake band 6 from and to permit rotation of the drum 5. In a convenient constructional arrangement according to the invention, the ends of the brake band 6 are secured to brake blocks 7 carried by pin and slot connections 9, 10 by levers 11 movable to apply the blocks 7 to or withdraw them from contact with the



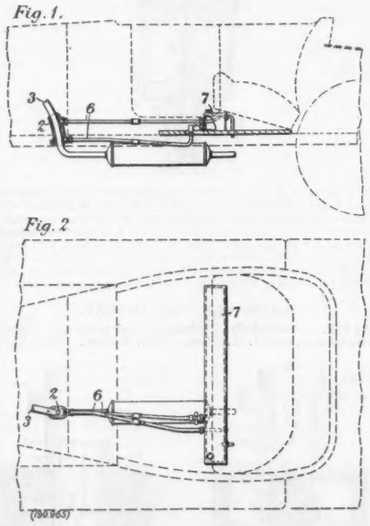
drum 5. The plungers 13 are moved apart by wedge or cam surfaces 15 provided on opposite sides of a longitudinally slidable bar 16, seen in transverse section arranged between the proximate ends of the plungers 13. With this construction, when the bar 16 is in a position in which the cams 15 are located between the plungers 13 to hold the same separated, with the springs 14 under compression, the levers 11 are moved to the positions indicated in broken lines, thereby carrying the blocks 7 out of contact with the brake drum and also slackening the band 6 so that the drum 5 can revolve freely so far as the action of the brake is concerned. If now the bar 16 is moved so that the cams are carried away from between the plungers 13, then the latter are moved by the springs 14 and bring the levers 11 to the positions in which they are shown in full lines, whereby also the blocks 7 are brought into contact with the drum. Assuming the drum to be revolved in counter-clockwise direction, as indicated by the arrow, the block at the right-hand side of the figure will, by its frictional engagement with the drum, be moved from the position indicated in broken lines to that indicated in full lines, thereby tightening the brake band 6. The brake block at the left hand side of the figure resting against a stop or abutment 17 on a convenient part of the frame or casing enclosing the drum acts as a fixed anchorage for the end of the brake band attached thereto. (*Accepted January* 17, 1923.)

191,143. W. Frost, London, and Harvey Frost and Co. Limited, London. Electrically-Heated Vulcanising Apparatus. (3 *Figs.*) October 4, 1921.—The invention relates to electrically-heated vulcanising apparatus. According to the invention, there is provided in vulcanising apparatus, a surface comprising a plate 12 to be heated, an electric heating element, a closed chamber situated between the heating element and the plate 12 and containing only such quantity of water as will be sufficient to fill the chamber with steam at the temperature appropriate to vulcanising and a switch in the circuit of the heating element. One pole of the switch comprises a stationary block 22, the other pole being constituted by a block 24 screwed on to the end of a rod 25 that slides in a guide 26 conveniently formed integrally with a plate 27. The part 27 is thermally



insulated from the electric heating element. The rod 25 is provided with a compression spring 28 which normally holds the part 24 in contact with the part 22, so that the switch is closed. This switch is provided with a thermostatic control which operates automatically to open the switch when the heated surface of the vulcaniser has attained a predetermined temperature. This automatic control is effected by using the pressure of the steam generated in the closed water chamber aforesaid; a suitable pipe connection 29 communicates at one end with the interior of this chamber, and at the other end with a chamber formed in a casing 30 at one end of the vulcaniser. One wall of this latter chamber is constituted by a flexible diaphragm which is distorted by the pressure of the steam, and such movement of the plate is transmitted by means of a rod 31 to the rod 25 of the switch. (*Accepted January* 17, 1923.)

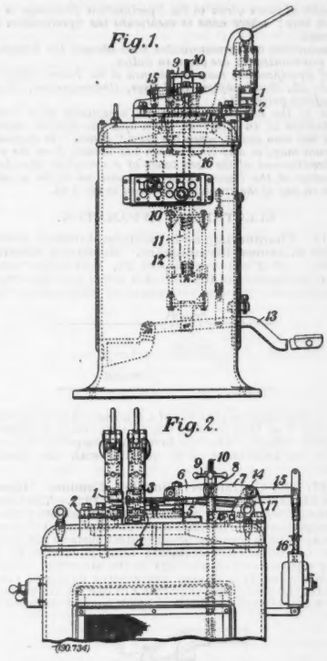
190,965. The Rover Company, Limited, Coventry, and S. G. Watson, Coventry. Heating Motor Cars. (2 *Figs.*) April 18, 1922.—The invention relates to hot water heating apparatus for motor vehicles of the kind in which a boiler surrounding the exhaust pipe is connected up with heat-radiating devices conveniently disposed within the vehicle. According to



the invention, the boiler 2, which takes the form of a muffle or sleeve around the exhaust pipe 3, is connected up with a heat-radiating device 7 within the body of the vehicle by means of flexible tubes 6 in order to provide for relative movement between the latter and the chassis and to facilitate detachment when the heating device is not required. (*Accepted January* 10, 1923.)

MINING, METALLURGY AND METAL WORKING.

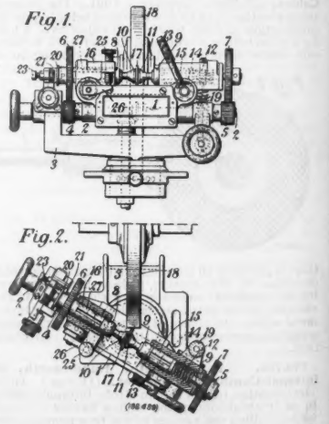
190,734. C. A. Hadley, Bradford, and A. I. Manufacturing Company, Bradford. Welding. (6 *Figs.*) June 22, 1921.—The invention relates to what is known as butt-welding. According to the invention, the operation of a starting lever sets in relative motion a pair of electrodes, the speed of displacement of which is independent of that of the starting lever and can be adjusted as desired throughout the range of travel of the electrodes. The work is clamped between electrodes 1, 2, 3, 4, the electrodes 3, 4 being mounted on a slide 5 connected to the end of a link 6 of a pair of links 6, 7 forming a toggle. The centre hinge pin 8 of the toggle is connected to an adjustable nut 9 on a spindle 10 connected by a spring 11 to a yoke 12 operated by a foot pedal 13. The outer hinge pin 14 of the link 7 also forms the pivot of a pair of bell crank levers 15, one connected to the piston rod 16 of a dash pot, whilst the other is connected to the rod of a trip switch. The outer arm 17 of one bell crank lever is coupled



to the sliding block 5. As the pedal 13 is depressed, the parts to be welded are brought into contact, whereupon the spring 11 is compressed to draw down the hinge pin 8 and turn the bell crank levers 15 about the pivot 14. The slide 5 will, however, only be displaced very slowly on its guides owing to the resistance of fluid such as oil, below the piston of the dash pot. (*Sealed.*)

MISCELLANEOUS.

188,489. A. B. Symons, London, and C. B. Ustonson, Palmer's Green. Lens-Edge Grinding Machines. (2 *Figs.*) October 7, 1921.—A machine for grinding square or bevelled edges on meniscus or periscopic lenses and adapted to be used also for other lenses, comprises spring or other means urging the lens across the face of the grinding wheel and a templet mounted on the lens-holder and co-operating with a member which engages the face of the templet. The lens is held between two discs 10, 11 mounted on spindles 8, 9 respectively, which are carried by a frame 1 pivoted on a spindle 2 supported in a frame 3. The spindle 2 drives the spindles 8, 9, through similar pairs of spur-gears 4, 6, and 5, 7, and the frame 1 is rocked on the spindle by a templet 20 mounted on the spindle 8, a spring 19 holding the lens 17 up to the grinding wheel 18 and the templet up to an adjustable finger 21 carried by the frame 3. The



spindle 9 is pressed axially by a spring 12 and also may be moved axially, for insertion or removal of a lens, by means of a pinion 14 movable by a lever 13 and engaging a rack on a sleeve 15 in which the spindle rotates; the spindle 8 also may be spring-pressed. The templet 20 is curved to agree with the curvature of the lens, and is pressed into contact with an adjustable screw 23 by the spring 12, so that, on rotation of the work-carrying spindles, the lens moves across the face of the grinding-wheel. In order to adapt the machine for grinding the edges of double-convex or plano-convex lenses, the sleeve 16 in which the spindle 8 runs has formed thereon a rack, which is engaged by a pinion 27 operated by an arm 26. The arm may be held against movement by a screw 25; for operating upon meniscus lenses, the screw is moved to free the arm. The frame 3 may be pivotally mounted so that the lens edge may be presented at an angle to the grinding wheel for grinding bevelled edges. (*Sealed.*)